SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JANUARY 1914.

GENERAL PHYSICS.

1. *Demonstration of Pendulum Law.* **A. Pizzarello.** (N. Cimento, 5. Ser. 6. pp. 407–411, June, 1913.)—Several devices are described for altering the restoring force in the case of a pendulum, with the object of showing that the period of oscillation always varies as the square root of the restoring force. S. G. S.

2. *Units of Force.* **O. Lehmann.** (Zeitschr. Instrumentenk, 33. pp. 279–280, Sept., 1913.)—With units the metre, the kilogramme, and the second, the unit of force becomes a decimegadyne. Call this a *Cop* (from Copernicus). Then 1 Cop × 1 metre = 1 Joule ; activity = 1 watt ; and other expressions are convenient. [See Abstract No. 546 (1913).] A. D.

3. *A Formula in Interpolation.* **L. H. Adams.** (Washington Acad. Sci., Journ. 3. pp. 469–474, Nov. 19, 1913.)—The author points out the limitations of the use of a formula of the type $y = a + bx + cx^2 + dx^3 + \dots$ for expressing experimental results. He suggests formulæ of the type $y = ax + b(1 - \epsilon^{cx})$ or $y = ax + b \log(\cosh cx)$ as useful in certain cases, and illustrates by numerical examples the great accuracy that can sometimes be obtained by their use. A. R.

4. *A Physical Interpretation of the Bessel Function of Zero Order.* **J. Hollingworth.** (Phil. Mag. 26. pp. 427–440, Sept., 1913.)—The author points out that mathematical physics can be considered from two points of view. In the first we consider the differential equation arrived at from first principles and solve it by purely formal mathematical methods. The solution is reinterpreted into physical ideas and applied to the problem in question. In the second way we proceed as follows. We regard the complex problem as a generalisation from the simple principles involved. These principles can be expressed mathematically, and, consequently, by generalising from these we may be able to build up the same solution as before. A solution of the equation $\partial^2 y/\partial x^2 + 1/x \, . \, \partial y/\partial x + y = 0$, is obtained by both methods, and so their relative values can be judged. A. R.

5. *The Increase in Projectile Velocity in Front of the Gun Muzzle.* **M. Ôkôchi.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 104–114, June, 1913.)—The author commences by pointing out the importance of projectile velocity in calculating ballistical effects. The muzzle velocity is generally determined by means of the Boulengé chronograph for artillery purposes, and takes the form of measuring the interval of time between the breaking of two current circuits, one being a thin wire stretched across the muzzle and the other an installation 50 to 100 m. away. From the average velocity so found, the muzzle velocity may be calculated by utilising a law of air-resistance. Many authorities consider that the method is not sufficiently exact, since the powder gases are active some metres beyond the muzzle, the latter observation having been first made by Crehore and Squier by means of their "polarising photo-chronograph." This result has since been obtained by Indra, who used the Boulenge chronograph, and Radacović with the condenser chronograph. A complete investigation resulted in establishing that the projectile velocity was greatest at the muzzle, decreasing up to 75 cm. away, and then increasing once more up to 165 cm. from the muzzle, when the velocity attained a second but smaller max. velocity. Investigations by W. Wolff with the 8-mm. rifle, using different charges, could establish no increase in velocity after leaving the muzzle, the latter velocity being the maximum from which a continuous decrease was recorded. The results of other investigators, together with those described, being so contradictory, the present author has made comprehensive experiments with the Japanese 6·5-mm. infantry rifle M/98. For this investigation a species of drum-chronograph was employed with a number of charged Leyden jars instead of induction spirals. The jars were so arranged that at the instant when the projectile passed any appointed position the corresponding jar emitted a spark which could be seen on a rapidly rotating drum. The author gives considerable details of his apparatus illustrated by a diagram, and discusses the possible sources of error. Tables, diagrams, and a mathematical discussion of the results obtained then follow. The author could not establish waves produced by the projectile shortly after leaving the muzzle, as it still lies in a rapidly moving medium, for the powder gases are travelling with almost double the velocity of the projectile, so that its velocity increases until the air-resistance begins to exert its influence. It is extremely probable that there is no minimum velocity between the muzzle and the point of max. velocity, and, further, that a continuous velocity-decrease from the mouth onwards only takes place in cases where the charge very quickly burns out and the muzzle pressure is extraordinarily low. The max. velocity of the projectile from the Japanese rifle M/98 was found at a distance of about 1·5 m. from the muzzle, and is about 0·8 per cent. greater than the muzzle velocity which the shot again possesses at about 5 m. from the muzzle.

H. H. Ho.

6. *Theory of Gravity.* **S. B. McLaren.** (Phil. Mag. 26. pp. 636–673, Oct., 1913.)—A mathematical and quasi-speculative essay on gravity based on (1) B. Riemann's view that the *ether* is a fluid and *matter* a region where the ether is continually destroyed, and (2) the modern principle of relativity.

E. H. B.

7. *Gravitation from the Standpoint of Relativity.* **G. Nordström.** (Ann. d. Physik, 42. 3. pp. 533–554, Oct. 16, 1913.)—A highly analytical treatment of the theory of gravitation on the relativity principle. The inertia and gravity

masses of a spherical electron are calculated, and the dependence of mass and length on gravitational potential are discussed. [See Abstracts Nos. 854 and 1250 (1913).] E. H. B.

8. *Relativity.* **R. A. Wetzel.** (Science, 38. pp. 466–474, Oct. 3, 1913.)—A semi-popular *résumé* of the theory of relativity illustrated by a relativity model showing two systems each capable of relative motion and each bearing two clocks which may be set at will. [See Abstract No. 2277 (1905).] E. H. B.

9. *Stationary and Moving Systems.* **K. Tamaki.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 235–252, May, 1913.)—A mathematical treatment by vector analysis obtaining symmetrical expressions of the relations between the physical quantities in the two systems. E. H. B.

10. *Motion of a Viscous Fluid.* **Rayleigh.** (Phil. Mag. 26. pp. 776–786, Oct., 1913.)—A mathematical discussion of the stability of certain fluid motions based on the works of Helmholtz (Collected Works, 1869) and Korteweg (Phil. Mag., 1883). E. H. B.

11. *Flow of Viscous Fluids through Orifices.* **G. F. Davidson.** (Roy. Soc., Proc. Ser. A. 89. pp. 91–99, Aug. 19, 1913.)—Describes experiments on drowned orifices using heavy engine oil as a fluid. The effects of the boundaries are examined. A baffle-plate one diam. from the orifice on the down-stream side produces no effect. Thus the results obtained are considered true within 1 % for one infinite fluid flowing into another through an orifice of the kind used. When water is used as a fluid the coefficient of discharge is about 1 or 2 per cent. less for drowned than for free discharge. Curiously, friction can increase the flow by preventing contraction of the issuing jet. The problem is discussed by the method of dimensions, and it is shown that the fundamental assumption that stress is proportional to strain in a viscous fluid is not true. Special experiments to determine the variation of viscosity with varying rates of distortion are described; the viscosity varies from 13·7 to 9·4 as the rate of distortion varies from 20 to 280. (Rate of distortion in a tube is defined as 8V/3R.) The variation of viscosity with varying rate of distortion precludes any application of the laws of similar flow because the rate of distortion varies from point to point and the corresponding changes in ν will alter the form of flow. H. S. R.

12. *Turbulence Viscosity of Water.* **W. Sorkau.** (Phys. Zeitschr. 14. pp. 759–766, Aug. 15, and pp. 828–831, Sept. 1, 1913.)—Discusses the formulæ for Hagen's turbulence viscosity as dependent upon temperature and pressure, and defends his own formula as against that of Schaefer and Frankenberg. The supposed "turbulence II" between Hagen's turbulence and the frictionless ("solid") flow is doubtful. The pressure at which the Poiseuille flow is pure stable quickly falls with a rising temperature. It is therefore very doubtful where the Poiseuille viscosity is really measured when examining a liquid in an Ostwald viscosity tube close up to the boiling-point. E. E. F.

13. *Inertia of Energy.* **P. Langevin.** (Journ. de Physique, 3. Ser. 5. pp. 553–591, July, 1913.)—Mass may be defined as: (1) an inertia coefficient; (2) a capacity for impulse or quantity of movement; (3) a capacity for kinetic

energy. It is a postulate of Rational Dynamics that these definitions are congruous and that mass is unaltered by mechanical, physical, and chemical changes. The constancy of mass is a consequence (1) of assuming inertia to be fundamental; (2) of assuming the equality of action and reaction; (3) of assuming the conservation of energy. Inertia can no longer be regarded as fundamental, as it is expressible, at least in part, electromagnetically. The three definitions are then congruous only when the velocity is small relatively to that of light; and even this *initial mass*, as it may be called, varies with every gain or loss of energy. Rational Dynamics must therefore be regarded as merely a first approximation, which, however, is sufficient for most purposes; and the conservation of mass as an approximate consequence of the more fundamental concept of the conservation of energy. The author traces the development of the electromagnetic expression of inertia from its origin in Maxwell's equations establishing the convection current, the creation by a moving charged body of an accompanying magnetic field; J. J. Thomson's analytic development; the experimental verification by Rowland and his pupils; down to Poincaré's proof that just as conservation of energy necessitated the localisation of energy in the electromagnetic field, so conservation of quantity of movement necessitated its similar localisation. Calling W_0 the initial energy of a body, W the energy absorbed, in virtue of its electric charge, in setting it in motion, W_e, W_m, the energy of its electrostatic and electromagnetic fields, respectively, then $W = W_e + W_m - W_0$. Since W becomes infinite for a body moving with the speed of light, the latter is necessarily a superior limit to the speed of any portion of matter, a result following as a consequence of the fact that the electromagnetic nature of light is itself a consequence of Maxwell's law of electric displacement.

When mass is defined as an inertia coefficient it can only give an electromagnetic mass, a function only of the velocity, provided that the electric and magnetic fields are wholly determined in terms of the velocity at any instant, and this will be the case only for *quasi-stationary* movements in which the accelerations are too small to give rise to sensible radiation. The principles of conservation then hold, and coefficients of inertia can be defined as quotients of the force by the acceleration which it produces. But there are two cases giving rise to different values: *longitudinal mass* when the force and velocity are in the same direction, so that the acceleration is a change in magnitude only; *transverse mass* when the force and velocity are at right angles, so that the acceleration is a change in direction only. For a total impulse G, and a velocity v, the value of the former is dG/dv, and that of the latter is G/v, which Poincaré has called the Maupertuisian mass [defined by (2)]. The latter is the simpler, and is, moreover, the mass concerned in the deviation of kathode rays, β-particles, etc., by electric forces perpendicular to their directions; it will therefore be taken as *the mass* simply. The expression of this mass as a function of the velocity is complicated if charge be supposed carried by undeformed sphere, but the assumption of the Lorentz-Fitzgerald contraction leads to the simple formula $m = m_0/\sqrt{1-\beta^2}$, where m_0 is the initial mass, its value at rest or low speeds, and β is the ratio of the speed to the speed of light. Moreover, it is in accordance with the Lorentz transformations which constitute the foundation of the *Principle of Relativity*, and as Einstein has shown, the contraction is merely one of the aspects of the modifications in the ideas of time and space involved in this principle. Further, as Poincaré has pointed out, non-electromagnetic forces are requisite to prevent dissipation of the charge of an electron, if regarded as a charge e, of surface density σ, on a sphere of radius

a. The simplest force would be a pressure $p = 2\pi\sigma^2/K_0 = e^2/8\pi K_0 a^4$, where K_0 is the specific inductive capacity of the ether, and supposing such a pressure everywhere exerted by the ether, the spherical electron would be deformed into an oblate spheroid having the polar semiaxis $a\sqrt{1-\beta^2}$. The potential energy at rest, E_0, is then shown to be related to the initial mass, m_0 by the simple expression $m_0 = E_0/c^2$, where c is the velocity of light. The consideration of a simple case then leads to the conclusion that a moving system will conserve its identity for an observer moving with it only if the ether pressure corresponding to the Poincaré pressure on the electron remain constant, and that the total impulse, in the direction of motion, will be $E\,v/c^2$, where v is the velocity of the system; and it is shown to follow from this that every variation in the internal energy of a system through emission or absorption of radiation must be accompanied by a corresponding diminution or increase in the inertia of the system. Mass must therefore vary with temperature and chemical changes. The amount of such change is found, however, to be too small to be verified by direct measurement. But it is noteworthy that the observed deviations of atomic mass from Prout's law are satisfactorily accounted for by these variations. If the velocity of light in space be taken as a fundamental unit, then the mass of a body will become identified with its total energy, and its initial mass with its internal energy.

G. W. DE T.

14. *Structure of the Atom.* **J. J. Thomson.** (Phil. Mag. 26. pp. 792–799, Oct., 1913. Paper read before the British Association at Birmingham.) —The author here attempts to construct an atom in which the transformation of radiant into kinetic energy would take place in accordance with Planck's law. The intra-atomic forces need not necessarily obey the observed electrostatic laws, which represent an averaged effect, and the author makes the initial assumptions that the forces acting upon a corpuscle in the atom are: (1) A radial repulsive force, varying inversely as the cube of the distance from the centre, diffused throughout the whole of the atom. (2) A radial attractive force, varying inversely as the square of the distance from the centre, *confined to a limited number of radial tubes in the atom.* It is of interest to note that very much the effect of the former would result from something in the structure of the atom which should make the moment of momentum of a corpuscle about an axis in the atom a universal constant. A corpuscle within a tube of attraction might be removed to infinity, in the tube, or by leaving it sideways and then coming under the uncontrolled action of the repulsion, and, by the conservation of energy, the work done against the attractive force must be the same in either case. The following results then follow mathematically, an integration constant being suitably chosen: (1) The kinetic energy with which a corpuscle is expelled from the atom by the impact of light of frequency n is proportional to nh, where h is Planck's constant, the well-known law of Photo-electricity. (2) Radiant energy of frequency n will be absorbed only in multiples of nh; for unless the corpuscle receive sufficient energy to displace it from the tube, it will be left vibrating with frequency n which will be dissipated by radiation, so that the light will be scattered without absorption. (3) The potential energy of a corpuscle entering the atom from outside will be converted into radiation of frequency n by multiples of hn; *e.g.* a kathode particle striking an atom will penetrate until stopped by the repulsive force, when it will be repelled and ejected. While within the atom it will be accelerated and will therefore emit radiation, constituting Röntgen rays, the frequency of which bears Planck's relation to the kinetic energy of the originating particle. (4) The total energy of the Röntgen radiation is proportional to the fourth power of the velocity of the kathode particles exciting it, a result given by the author [Abstract No. 1669 (1907)] and confirmed by Whiddington's experiments [Abstract No. 558 (1912)]. Taking Whiddington's value for the velocity of kathode particles requisite to excite K radiation, and applying it to a hydrogen atom of type here considered, the frequency obtained corresponds to ultra-violet light, coinciding with the head of the series of H lines given by Balmer's law, so that the spectrum represents the K radiation for H. Hydrogen possesses in the Schumann region a spectrum of still greater frequency, and it seems probable that the K radiation may not be the hardest type of Röntgen radiation. Helium atoms may also give rise to Röntgen radiation in the Schumann region, but for heavier elements the frequency would be of an order corresponding to Röntgen rays.

G. W. DE T.

15. *The Constitution of Atoms and Molecules.* II. **N. Bohr.** (Phil. Mag. 26. pp. 476–502, Sept., 1913.)—[For Part I. see Abstract No. 1930 (1913).] Regarding an α-particle as identical with the nucleus of a helium atom, in accordance with the author's fundamental hypothesis, the formation of a helium atom from α-rays will afford an example of the binding of an electron initially at rest, accompanied by radiation, which will occur successively until the system becomes neutral and can no longer sensibly affect distant electrons. The smallness of the nucleus will prevent its internal structure sensibly affecting the constitution of the electron cluster, and therefore the physical and chemical properties of the atom. These will depend only on the charge and mass of the nucleus, its structure conditioning the radio-activity only. The experimental evidence, especially on the scattering of radiation [A. van den Broek, Abstract No. 708 (1913); Geiger and Marsden, Abstract No. 1296 (1913); C. G. Barkla, Abstract No. 720 (1912)], supports the hypothesis that, with few exceptions, the number of electrons in a neutral atom is the number indicating the position of the corresponding element in the series of increasing atomic weight; *e.g.* the O-atom, being eighth in the series, should have eight electrons and a nucleus carrying eight unit charges. Then, on the assumption previously made that in the permanent state the angular momentum of every electron about the orbital centre is equal to $h/2\pi$, and that the condition of stability is that the total energy of the actual configuration is less than that of any neighbouring one satisfying the former condition, it is shown that the configuration, *i.e.* the frequency and linear dimensions of the rings, is completely determined, given the nuclear charge and the numbers of electrons in the different rings, but that corresponding to different distributions of the electrons in the rings, there will, in general, be more than one configuration satisfying the conditions of angular momentum and stability. Imagine the electrons in a ring to undergo very slow displacement from extraneous forces parallel to the axis. Their instantaneous motions will then remain parallel to the plane of the ring, the angular momenta will remain constant, and the gain of energy will be measured by the work done by the extraneous forces. It is therefore assumed that the ordinary mechanics apply to the electron vibrations perpendicular to the plane of the ring, although not to those in this plane, an assumption supported by the apparent agreement with Nicholson's observations [Abstract No. 1930 (1913)], and, as shown later, with dispersion experiments.

In seeking for indications of the particular possible configurations corresponding to existing atoms, the number of electrons in the atom is assumed equal to the number indicating the position of the corresponding element in the periodic series of increasing atomic weight, except only where deviations from the periodic law are observed. The symbol N $(n_1, n_2, \ldots)$ will represent a plane system of N rings with nucleus Ne, and with $n_1, n_2, \ldots$ electrons in each ring, beginning with the inner ; $a_1, \ldots, \omega_1, \ldots$ will represent the radi and frequencies ; and $W[N(n_1 . n_2, \ldots)]$ will represent the energy emitted during formation. Then for a neutral H-atom 1 (1), $a = 0{\cdot}55 \times 10^{-8}$, $\omega = 6{\cdot}2 \times 10^{15}$, $W = 2 \times 10^{-11}$, values of the orders to be expected ; *e.g.* $W/e = 0{\cdot}043$, or 13 volts, while the ionising potential of a H-atom is found by J. J. Thomson to be 11 volts [Abstract No. 1870 (1913)]. Since $W[1(2)] > W[1(1)]$ a H-atom should be capable of acquiring a negative charge, as agrees with experiments on positive rays, but not of acquiring a double negative charge, since $W[1(3) = 0{\cdot}54.10^{-11}$ only. For the permanent state of a positively-charged He-atom, 2 (1), $a = \frac{1}{2}a_0$, $\omega = 4\omega_0$, $W = 4\ W_0$, where a_0, ω_0, W_0 are the values for 1 (1). For considerable distances the system 2 (1) will act on a free electron as a simple nucleus of charge e, so that stationary states in which the most lightly bound electron moves as in H-atom may be assumed, but concentric rings would be too near for stability, so two confluent rings or two rings of equal radii in parallel planes will be the configuration suggested. The addition of a further electron would lead to a smaller value of W, indicating that a negative charge cannot be acquired, which agrees with experiment [Abstract No. 1479 (1910)]. For neutral Li and Be atoms the author arrives at the configurations 3 (2, 1) and 4 (2, 2), passing through the formation stages 3 (1), 3 (2), and 4 (1), 4 (2), 4 (2, 1) respectively. Negatively-charged atoms 3 (2, 2) and 4 (2, 3) may be formed from these, and in the latter case there will still remain a definite, though very small, affinity for free electrons.

Now suppose that in two coplanar rings the electrons in one act on those in the other as though the charge were uniformly distributed round the ring, still, with this approximation, conserving the constant angular momentum of the electrons and the stability for displacements perpendicular to the plane. Let the inner ring now be pulled slowly to one side of the plane by applied forces parallel to the axis. Then the repulsion of the inner ring will cause the outer one to move to the opposite side of the plane. During the process one ring will increase and the other diminish in radius. At a certain distance apart they will be in equilibrium, but the only stable case is that of two rings with equal numbers of electrons, when the configuration may be stable for equal radii, the electrons in one ring being opposite the intervals between the electrons in the other, for this corresponds to the smallest total energy. Otherwise the rings will either return to their original positions or interchange them. With uniform distribution of the charge round the rings there could be no confluence, but, taking account of the discrete distribution, this is found possible when the numbers of electrons are equal and the rotations in the same direction. They will then unite, provided the final configuration be stable, in which case the electrons in one ring will be equally interspersed between those in the other. The constancy of angular momentum is then obviously satisfied. If the charge of the nucleus be very great, the rings of electrons first bound, if few in number, will be very close together, giving very unstable configuration, and facilitating gradual interchange of electrons, but otherwise there will be confluence only between rings with equal numbers of electrons, so the numbers on inner rings should be only 2, 4, 8, ..., a conclusion strongly supported by the fact that the chemical properties of the elements of low atomic mass vary with a period of 8. Further, the number of electrons in the outer ring will be odd or even according as the number of the electrons in the atom is odd or even, which bears a suggestive relation to the fact that the valency of such an element is odd or even according as its number in the periodic series is odd or even.

G. W. DE T.

16. *Determination of Gaseous Molecules by Maxwell's Theory.* **P. Kotournitzky.** (Russian Physico-Chemical Soc., Journ. 44. 3. pp. 151–156, 1912.)—The author gives a theoretical discussion of the question based upon Maxwell's theory, in the course of which he obtains a table from which the co-ordinates F, X, Y were determined for intervals 0–1, 1–2, 2–3, and also for intervals between interval (0–2) divided into five equal parts. In the following table are shown the nearest dimensions for the number of molecules (Σn_u) and their kinetic energy ($\Sigma mnu/2\,u^2$), in round percentages of the total number of molecules (N) and full amount of kinetic energy of the gas ($muk^2/2N$), neglecting fractions of percentages :—

$u/w = s =$	0–0·4	0·4–0·8	0·8–1·2	1·2–1·6	1·6–2	2–3	0–3
Number of molecules	4	22	32	25	12	5	100
Kinetic energy	0	6	22	32	25	15	100

Comparing intervals 0·8–1·2 and 1·2–1·6 we notice in the last the kinetic energy (32 : 22) is 10 % greater than in the first, although the number of molecules in the last case is 7 % smaller than in the first ; and this is explained by their greater velocity. The total of these three intervals, $22 + 32 + 25 = 79$, already reaches 79 %, the rest accounting for only 21 % of the full number of molecules and full kinetic energy of the gas. I. P.

17. *Molecular Currents and Temperature Discontinuity.* **H. Bolza, M. Born,** and **T. v. Kármán.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 221–235, 1913.)—A supplement to the kinetic theory of rarefied gases dealing with: (1) Flow of a gas through a solid grating ; (2) pure molecular flow ; (3) comparison with Kundsen's formula. E. H. B.

18. *Kinetic Theory of Surface Tension.* **E. Madelung.** (Phys. Zeitschr. 14. pp. 729–731, Aug. 15, 1913.)—The law of Eötvös (1886) is an empirical relation between the surface tension α of a liquid, the molecular volume V_0, and the temperature T of the form $\alpha\, V_0^{2/3} = K(T' - T)$, where K is a constant of the mean value 2·12 and T′ is a temperature not far from the critical temperature. The author endeavours to derive this law from molecular theory. Assuming the equipartition of energy, the molecules at the surface and in the interior must have the same energy, and as the forces at the surface are feebler the amplitude of oscillation must be greater. The "oscillation volume" is therefore compressed when a portion of liquid is brought from the surface to the interior, as when two cm.^{2} of surface layer are brought together with their flat faces. The calculation requires a knowledge of the number of molecules per cm.^{3}. This is made possible by assuming that in the liquid state the distribution of molecules is also by space lattices. The author gives on this basis a theoretical deduction of the law. The constant is of the same order of magnitude as the empirical constant.

E. E. F.

19. *Kinetic Theory of Surface Tension.* **M. Born** and **R. Courant.** (Phys. Zeitschr. 14. pp. 731–740, Aug. 15, 1913.)—The authors apply Debye's

method of evaluating specific heats to the problem of the relation between temperature and surface tension. One is justified in the case of liquids, even more than in the case of solids, in regarding the isotropic body as a continuum. It is assumed that the thermal oscillations of a liquid take place under the influence of cohesive forces, such as are evidenced by surface tension at the surface, and by compressibility in the interior. The treatment is purely phenomenological, and the laws of hydrodynamics and capillarity are used in a merely formal manner. The molecular conception only enters where, out of the infinite number of vibrations of the continuum, the first 3 N are identified with molecular vibrations. When the distribution of vibrations is thus found, the free energy of the liquid is calculated from Planck's resonator formulæ, as in solids. The law of Eötvös then becomes a special case of a more general formula. E. E. F.

20. *On Radiation Equilibrium and Atmospheric Radiation.* **R. Emden.** (K. Bayer. Akad. München, Ber. p, 55, 1913. Meteorolog. Zeitschr. 30. pp. 452–454, Sept., 1913.)—The isothermal conditions in the stratosphere show that the air is in radiation equilibrium there, each particle losing by radiation as much heat as it gains through the same agency. Gold, in his work on the subject, made the assumption that radiation equilibrium implied that the streams of energy passing up and down through a given layer were equal to one another. This is true if the spectra of the two streams are identical; but it would not be true if, for example, the downward and upward streams consisted respectively of a short-wave and a long-wave radiation. Radiation equilibrium would obtain if the former stream were in excess of the latter, provided the absorption were less in the downward than the upward stream. If the earth radiates as a "black" body, and the atmosphere as a "grey" body throughout the spectrum, it can be computed that when radiation equilibrium is attained, the atmosphere is isothermal and its temperature is 254° A. As, however, the atmosphere does not radiate as a "grey" body throughout the spectrum, it cannot be isothermal under radiation equilibrium, but the difference between up and down radiation is then constant at each point. Assuming as a first approximation that the atmosphere may be divided into two parts, the stratosphere, in which there is no appreciable water-vapour, and the troposphere, where the mean amount of water-vapour is approximately known by observation, and assuming further that in the two parts the atmosphere acts as two unequally "grey" bodies, a table of temperatures under radiation equilibrium is obtained, which shows a minimum temperature of 216° A. at 11¼ km., gradually rising to 254° A. at the extreme limit of the atmosphere. Below 11¼ km. temperature rises, at first very slowly, but at 8 km., where the temperature is about 236° A., the vertical temperature gradient becomes equal to the adiabatic. Below 8 km. the gradient continues rapidly to increase, and at the surface (temperature 289° A.), it is 2·85° C. per 100 m. Thus in the state of radiation equilibrium the atmosphere in the troposphere above 8 km. would be in stable equilibrium, while below 8 km. the equilibrium would be unstable and convection would ensue, thus disturbing the radiation equilibrium and conveying heat up to the stratosphere. R. C.

21. *Computation of the Radiation Equilibrium of the Atmosphere.* **K. Schwarzschild.** (Meteorolog. Zeitschr. 30. pp. 454–456, Sept., 1913.)—In Emden's paper [see preceding Abstract] the computation of atmospheric temperatures in the case of radiation equilibrium is carried out for the special case in which the coefficients of absorption in the two parts of the atmosphere considered are certain definite functions of the air mass per unit volume. The author shows how the computation may still be performed in the more general case, when the coefficients of absorption are any functions of the mass per unit volume. R. C.

22. *Curious Formation of Cirrus Cloud.* **P. Flajolet.** (Comptes Rendus, 157. pp. 558–560, Oct. 6, 1913.)—Birkeland has recently suggested that a possible mode of production of cirrus may be looked for in the effects produced by secondary electric currents in the earth and the lower part of the atmosphere surrounding it. The primary currents which induce the secondary currents are those circulating in the higher layers of the atmosphere, and they are due to helio-kathodic rays deflected towards the earth by its magnetism.

On Sept. 20, 1913, about 20 parallel bands of cirrus were observed at the observatory of S. Genis-Laval, in the evening. The system of bands crossed the zenith, where it was about 30° wide, and its direction was nearly at right angles to the magnetic meridian. After about 20 minutes the bands began to disappear at their western end, but until the time of final disappearance the mean direction remained unaltered. The curves of horizontal and vertical components of magnetic force showed no unusual features at the time, but the magnetic declination was slightly disturbed; a maximum having occurred 25 mins. before the bands were first noticed, and a minimum being noted 30 mins. after the maximum. The amplitude of the disturbance was 1¼′. R. C

23. *Atmospheric Transmission of Earth Radiation.* **A. Ångström.** (Astrophys. Journ. 38. pp. 198–200, Sept., 1913.)—In view of the discordances between the estimates of various observers for the coefficient of transmission of earth radiation by the atmosphere (Very's estimate is 40 %; Abbot and Fowle's 10 %), an examination is made of the results of observations of atmospheric radiation at different heights above sea-level. The conclusion is that the transmission for clear sky is seldom greater than 25 % or less than 5 %. C. P. B.

24. *Undagraph, Wave-counter.* **O. Klotz.** (Nature, 92. pp. 97–98, Sept. 25, 1913.)—In connection with the Dominion Astronomical Observatory, Canada, a wave-counter, or undagraph, has been installed at Chebucto, near Halifax, Nova Scotia, on a granite cliff 110 ft. high facing the Atlantic. Recent investigations in seismology have tended to show that microseisms, or earth tremors, are largely due to the impact of the breaking seas during storms; these show specially from autumn to spring, during the winter stormy season. Their period ranges from 4–7 secs., while their amplitude appears to vary with the gradient of the "low" on the water along the coast. Results are to be published as soon as available. C. P. B.

25. *Greatest Magnitudes of the Intensity of Solar Radiation Observed at Pavlovsk from 1892. Enfeeblement of the Radiation in the Second Half of 1912.* **C. I. Savinov.** (Acad. Sci. St. Pétersbourg, Bull. 12. pp. 707–720, Sept. 15, 1913.)—Actinometric observations have been taken at Pavlovsk regularly since Sept., 1892. Since that time Ångström's differential pyrheliometer and Chwolson's actinometer have been used. The author examines the results which have been obtained, and affords comparisons between the instruments used at Pavlovsk and those of the Smithsonian Institution, and Potsdam. A

chart showing the monthly maxima of the intensity of solar radiation from the year 1892 is given in the original, according to the observations at Pavlovsk, and in the table below are exhibited the exact figures for each of the twelve months in order.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.
1892	—	—	—	—	—	—	—	—	**1·40**	1·20	1·06	—
93	0·93	(1·08)	**1·39**	(1·43)	1·41	**1·40**	1·34	**1·35**	1·37	1·26	1·01	—
94	0·93	(1·12)	1·32	(1·33)	1·37	(1·30)	(1·30)	(1·25)	(1·24)	1·22	1·12	0·86
95	—	1·19	1·36	(1·37)	1·32	(1·30)	(1·17)	1·33	1·32	(1·03)	(0·93)	0·91
96	1·09	1·26	1·38	1·34	1·40	1·25	1·30	—	1·26	1·20	0·88	**0·95**
97	—	1·20	1·27	(1·42)	(1·32)	(1·34)	1·27	1·18	1·34	(1·05)	0·92	0·90
98	**1·13**	1·11	(1·38)	**1·45**	(1·35)	(1·33)	—	1·27	—	**1·30**	1·00	0·76
99	1·07	(**1·30**)	1·38	1·40	1·35	(**1·40**)	(1·32)	(1·19)	1·20	(1·21)	1·03	—
1900	(1·01)	1·21	1·35	1·32	1·34	1·32	1·23	1·25	(1·27)	(1·12)	(0·88)	0·77
01	0·80	(1·18)	1·35	1·39	**1·44**	1·25	(1·29)	(1·30)	1·23	(1·10)	0·95	—
02	—	(1·22)	(1·33)	1·42	1·37	1·29	1·26	(1·25)	(1·21)	(1·17)	0·93	—
03	0·64	(1·00)	1·16	(1·18)	1·24	(1·16)	1·21	1·17	1·19	(1·04)	0·95	0·60
04	0·78	0·94	1·34	1·33	1·24	1·24	(1·24)	1·20	1·24	1·19	—	0·69
05	0·88	1·10	1·32	1·29	1·37	1·23	—	1·34	(1·29)	1·18	—	(0·78)
06	1·07	(1·02)	1·36	1·36	1·36	1·30	1·30	1·26	1·35	**1·30**	**1·13**	(0·78)
07	1·02	1·17	1·38	1·34	1·28	1·26	1·16	1·15	1·20	1·14	0·84	0·66
08	(0·73)	(0·92)	1·24	1·32	1·34	1·37	1·34	1·25	1·23	1·22	1·10	—
09	(1·05)	1·09	1·24	(1·27)	1·38	1·37	**1·35**	(1·29)	1·33	1·27	1·02	—
10	(0·92)	1·15	1·34	1·38	1·31	1·34	1·30	**1·35**	1·38	1·27	1·06	—
11	0·94	1·23	1·35	1·40	1·33	1·37	1·34	1·30	(1·14)	1·26	—	(0·88)
12	1·05	1·23	1·30	1·35	1·39	1·33	1·02	1·00	0·70	0·80	(0·52)	(0·39)
13	0·76	1·01	1·21	1·16	—	—	—	—	—	—	—	—

Anomalous radiation is noticeable during the second half of the year 1912, more so than in 1903–1904 and in 1907–1908. It is not possible to attribute the anomalies to the weather, but they are rather more likely to be due to the eruptions of volcanoes. The dust projected would cause a sudden declension in the intensity of radiation as observed on the earth, and there would be a much more gradual return to a normal state of things as the dust was slowly dispersed or deposited. The evidence obtained elsewhere is in favour of this view. The eruptions of Mont Pelée, and that in Alaska in 1912, not to speak of Krakatoa, were known to have a widespread effect. The

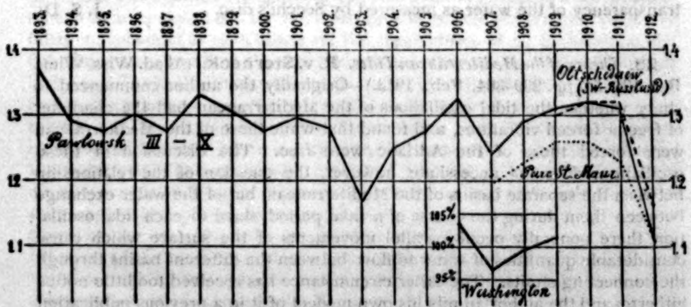


chart here reproduced compares the records for a few years of Pavlovsk, Nizni Ottschedaew, Paris, and Washington, which favour the assumptions of the writer. E. O. W.

26. *Water and the Magmatic Gases.* **A. L. Day** and **E. S. Shepherd.** (Washington Acad. Sci. Journ. 3. pp. 457–463, Nov. 4, 1913.)—From observations made on the Kilauea crater W. L. Green in 1887 and A. Brun in 1911 concluded that water of magmatic origin is not found among the gases exhaled by active volcanoes. Neither of the observers studied the gases at the point where they issued from the crater. The present authors descended into the Kilauea and inserted a tube directly into one of the cracks near the lava lake from which burning gas was rising; by a pipe-line, 8 m. in length, the tube was connected with a train of collecting tubes and a piston pump. As soon as the pump was worked, water was seen to condense in the glass tubes; this water served as a wash bottle. The analyses, partly made at Hawaii and mostly in Washington, proved the presence of many gases, SO_2, CO_2, CO, H, N, which, at the high temperature, above 1000° C., could not be in equilibrium. The actual percentage of water could not be determined; the condensed water contained oxides of Na, K, Ca, Fe, Al, further SO_3 and traces of NH_3, Cl, F, TiO_2. But there was no chlorine in the gas, nor was any argon or other rare gas found; this absence of argon is striking. The very small percentage of chlorine found agrees with the analyses of lava which had for years been exposed to the smoke cloud from the crater. H. B.

27. *Absorption of the Sun's Energy by Lakes.* **E. A. Birge.** (Science, 38. pp. 702–704, Nov. 14, 1913.)—Observations on the intensity of the solar radiation at different depths below the surface have been made on several of the inland lakes of Wisconsin. The amount of energy at 1 m. below the surface varies from 2 to 20 % of that at the surface. As a rule the depth at which 1 % of the surface energy is found lies between 3 and 4 m., while practically no heat radiation ever penetrates below 6 m. The percentage of the surface energy found at any given depth does not show much proportionality to the transparency of the water as measured by Secchi's disc. J. S. Di.

28. *Theory of the Mediterranean Tides.* **R. v. Sterneck.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 299–364, Feb., 1913.)—Originally the author commenced to study whether the tidal oscillations of the Mediterranean had the character of free or forced vibrations, and found that while those of the Mediterranean were forced those of the Adriatic were free. The discussion of these oscillations does not necessitate, however, the question of the relationship between the separate basins of the Mediterranean, but of the water exchange between them during the course of a tidal period, since to each tidal oscillation there generally occur parallel movements of the surface which cause considerable quantities of water to flow between the different basins through the connecting straits. The latter circumstance has received too little notice hitherto, and the author admits his own neglect of it in a previous publication on tidal phenomena in the western Mediterranean [see Abstract No. 861 (1913)]. The present paper is an attempt to deal with the whole of the available data so as to produce a comprehensive solution. A sketch of the equilibrium theory of tides is first undertaken with mathematical treatment, followed by a discussion of tidal phenomena in the Mediterranean and in the Black Sea. The results of the latter discussion are then compared with

those given on the equilibrium theory, and a formula for calculating the oscillation period is established. The case of the Black Sea then receives special treatment, as here the conditions are the least complex since the sea is practically a separate entity. Following this comes a discussion of the oscillation period of the western basin of the Mediterranean together with an estimation of its water balance. The important problem of the currents through the Gibraltar Straits then receives exhaustive treatment, and this section of the paper concludes with an elaborate theoretical examination of the oscillation period of the western basin. The eastern basin next receives attention, the particular case of the Adriatic Sea, including its special oscillation period and water balance, being carefully investigated, and an amended theory proposed. The conclusions arrived at are summarised by the author as follows:—(1) In the western basin the oscillations take place about an eccentric Spanish-Algerian nodal line determined by the author in the previous paper referred to; in the eastern basin and in the Black Sea the nodal line must, in the absence of positive data, be placed provisionally in the middle between the east and west boundaries. The Adriatic Sea, however, undergoes complicated oscillations, since high water makes the circuit once in 12·8 hours, and this is the case also of the Sicilian Sea which is the central portion between the two larger basins. (2) The equilibrium theory, according to G. H. Darwin, is still applicable to seas of dimensions similar to those of the Mediterranean basins. According to the latter the average port time of the basin must always amount to 3 o'clock in the West and 9 o'clock in the East; in reality, however, retardation of these times should be expected on account of the inertia of the water, a circumstance actually occurring in the eastern basin and the Black Sea. In the western basin, on the contrary, small accelerations are found which necessitate special explanation. In the Adriatic Sea a direct reversal of these port times is observed. The amplitude dimensions tolerably agree in the western and eastern basins, and also in the Black Sea, with those calculated on the equilibrium theory, but in the Adriatic the observed amplitude is nine times the calculated and in addition has a contrary phase. (3) Although G. H. Darwin regarded the Gibraltar currents as unimportant and the Mediterranean as an enclosed sea for tidal purposes in which the separate parts are fairly independent of each other, yet the observations of C. S. Nares on the Gibraltar currents and on the water movements through the channel between Sicily and Tunis, the Straits of Messina, and from the Adriatic through the Straits of Otranto, show that as exact a water balance as possible is maintained. (4) The water entry into the western basin produces a surface elevation of 13·3 cm., while a corresponding depression takes place during the water exit. This movement combined with the tidal oscillation causes an appreciable shifting of the nodal line towards the west, and affords the only explanation of its eccentric position. (5) The variations of the port times of the western basin are explained by the author as due to the influence of high and low water in the neighbouring Atlantic on the Gibraltar currents. (6) In the Adriatic the periodic entry and exit of 16·5 cubic kilometres of water through the Straits of Otranto produces a rise and fall of the surface of 11·2 cm., and this movement, combined with the tidal oscillation, accounts for the eccentric character of the nodal lines. (7) The special oscillation periods in the western and eastern Mediterranean and in the Black Sea cause the conclusion to be drawn that the oscillations are forced, while the corresponding data for the Adriatic point to the oscillations being free. H. H. Ho,

29. *The Distribution of Ocean Temperatures along the West Coast of North America deduced from Ekman's Theory of the Upwelling of Cold Water from the Adjacent Ocean Depths.* **G. F. McEwen.** (Internat. Review of Hydrobiology and Hydrography, pp. 243–284, 1912.)—It has long been known that the temperature of the sea water contiguous to the west coast of N. America is abnormally cold in comparison with the ordinary sea temperature for the same latitudes. Many theories have been put forward in the past to explain this phenomenon. The chief are reviewed in this paper and found to be unsatisfactory. It has been customary when dealing with ocean currents to adopt Zoeppritz's theory on the relation between these and the prevailing winds. This theory took no account of the earth's rotation. The chief deductions were (1) that the current produced was in the same direction as the prevailing wind at all depths, and (2) that a period amounting to several hundreds of years would be required for the surface current produced by the wind to be transmitted in one half its intensity to a depth of 100 metres. Recently Ekman has put forward a theory which takes account of the earth's rotation. This leads to results entirely different from Zoeppritz's. Thus the surface current flows in a direction 45° to the right hand (in the northern hemisphere) of the wind, and at successive lower layers the direction becomes more and more to the right, until it is directly opposed to the wind at a depth D where the velocity is one-twentieth of its surface value. This is in an infinite ocean of considerable depth. The depth at which this complete reversal occurs depends on μ, the coefficient of viscosity, the value of which must be modified to take account of the turbulence between adjacent layers of water. The value of D is then found to be 75 metres. Other problems are dealt with in the same way, where the infinite ocean of considerable depth is replaced by certain other assumed conditions. An application of these theoretical results to the general conditions prevailing along the west coast of N. America gives good qualitative agreement with the observed facts, the low sea temperature being accounted for by the upflow of cold water from the outlying sea bottom. This upflow would be expected from an application of the theory to the local conditions. Monthly surface sea temperatures are calculated for four stations making use of the known mean monthly wind velocities, and good agreement is obtained between the observed and calculated values. The paper concludes with an examination of the relation between the surface sea temperature and that of the adjacent land. J. S. Di.

30. *Axial Variations in the Earth as the Cause of Earthquakes.* **R. Spitaler.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 479–501. March, 1913.)—The author commences by referring to Milne's work on "Seismological Observations and Earth Physics" (Geographical Journal, 1903). In this Milne shows that the number of earthquakes increases with the size of the polar changes, and that rapid directional movements coincide with greater earthquake frequency. The present author therefore considers that by the study of axial fluctuations an explanation of terrestrial surface changes may be found, and his paper is a mathematical discussion of the axial movements, the results of which are supported by earthquake data. As an example of the latter the case of the two great San Francisco earthquakes may be quoted where prior to the catastrophe the polar movement underwent a rapid change in direction, so that this constituted the primary phenomenon whereas the earthquake itself was secondary. H. H. Ho.

31. *Spectrographic Measures of Solar Rotation.* **J. Evershed** and **T. Royds.** (Roy. Astronom. Soc., M.N. 78. pp. 554–562, June, 1918.)—During the dry seasons of 1911 and 1912 at Kodaikanal advantage was taken of days of exceptional clearness, when the sky appeared quite clear from diffuse cirrus cloud, to obtain high dispersion spectra of the east and west limbs of the sun and of the centre of the disc, for the purpose of studying the displacements towards the red of certain lines of iron and nickel at the sun's limb. These measurements gave values of the rotation decidedly smaller than those obtained by Adams in 1908. In the autumn of 1912 preparations were made for a new series of comparisons, the spectra of the two limbs and centre to be exposed simultaneously in order to avoid any instrumental error. Meanwhile the observations by Hubrecht at Cambridge were published, these agreeing closely with the Kodaikanal values in two respects : (1) the lower equatorial velocities, and (2) the variation between plates obtained at different dates. In view of a real change of velocity between epochs of maximum and minimum the new series were obtained during the early months of 1918. Three series were obtained in the period 1918 Jan.–April. Grouping the results of these a progressive change of velocity is clearly indicated, varying from 1·990 to 1·900 km./sec. This would indicate that it is not possible to derive reliable measures of the equatorial velocity from observations extending only over a few months. There appears to be a connection between rotation speed and sun-spot disturbances, probably dependent on proper motion of the vapours in the reversing layer, times of max. spot development being associated with large proper motion in the direction of the solar rotation. C. P. B.

32. *Anomalous Dispersion in Solar Phenomena.* **D. Brunt.** (Roy. Astronom. Soc., M.N. 78. pp. 568–600, June, 1918.)—Three theories of the equilibrium of the solar atmosphere are considered, but it is concluded that they cannot account for an atmosphere extending to the actual height observed. The effect of anomalous scattering is completely masked by the true absorption effect. The observed differences between the Fraunhofer lines at the centre and limb of the sun do not agree with the requirements of the anomalous refraction theory. It is also shown that anomalous refraction, whether the solar atmosphere has a tubular structure or a system of irregular density gradients, cannot account for the double bright reversal of H and K which is observed over the whole disc, and particularly over the calcium flocculi. As regards the chromosphere and prominences, no definite criterion could be found to decide between the anomalous dispersion theory and the selective emission theory. In the case of all the other phenomena the criteria available are unfavourable to the idea of anomalous dispersion having any important effect in solar phenomena. C. P. B.

33. *Interpretation of Photospheric Phenomena.* **W. H. Julius.** (Astrophys. Journ. 88. pp. 129–140, Sept., 1918.)—In presenting a discussion of various views concerning the nature of the solar photosphere, a new dioptrical interpretation is suggested, attributing many of the phenomena to a modification of ray-curving by gases having certain density gradients. C. P. B.

34. *General Magnetic Field of Sun.* **G. E. Hale.** (Astrophys. Journ. 88. pp. 27–98, July, 1918.)—Since the classic experiment by Rowland of producing a magnetic field by rotation of an electrically charged disc [Abstract No. 781 (1918)], various views as to the causation of terrestrial magnetism have

been formulated, and the author presents a short summary of these publications. So many ideas connected with the solar phenomena depend for their satisfactory explanation on the view of the sun acting as a magnet that a very rigid determination was planned with the powerful spectrographic equipment of the Mount Wilson Solar Observatory. The only method of direct observation consists in the examination of the Zeeman-effect on solar spectrum lines. If the field be strong enough, and the observer is supposed to be looking along the sun's axis, certain of the lines would be split into doublets, with components circularly polarised in opposite directions. For the investigation of this the solar light is passed through a Nicol prism and a quarter-wave plate before it reaches the slit of the spectrograph. In practice, on account of the weakness of the sun's magnetic field as compared with the field of sun-spots, complete separation into doublets is not to be expected; and, further, the observer is generally looking in directions considerably removed from that of the sun's axis. The most favourable position for observation is latitude 45°, where the effect of the ellipticity of the light of the components is overcome by the increased strength of the field. After a long analysis of the observed displacements, it is concluded that the results are in harmony with the idea that the sun is a magnetised sphere. On the assumption that the magnetisation is due to rotation, the sun's charge would be negative, the polarity corresponding to that of the earth. The determined strength of the field at the sun's pole is 50 gauss. A further extended investigation of the solar magnetic field at various levels is to be made in the near future, and will be carried on throughout the sun-spot cycle to ascertain if any variation occurs in relation to that of the sun's activity. C. P. B.

35. *Displacement Curve of Sun's Magnetic Field.* **F. H. Seares.** (Astrophys. Journ. 38. pp. 99–125, July, 1913.)—In a recent paper [preceding Abstract] Hale has described the results of an investigation for determining whether the sun possesses a general magnetic field similar to that surrounding the earth, the conclusion being in favour of its existence. In order that there might be a more rigorous control of the results, the observed displacements have been compared with the theoretical displacement curve derived on the assumption that the sun is a magnetised sphere, this investigation being the basis of the present paper. The equation connecting the displacement of a spectrum line with the solar magnetic elements, the co-ordinates of the observer, and the observed point, was established. The discussion is restricted mainly to the case of the simple Zeeman triplet. The effect on the displacement curve, of the elliptic polarisation introduced by the reflections from the silvered surfaces of the coelostat mirrors is also fully considered. It is found that for a normal Zeeman triplet the theoretical displacement curve is a function of the heliographic latitude, the position of the observer, and the solar magnetic elements, and is a sine curve differing but little from $k\Delta = 3 \sin 2\phi$, where k is a constant depending upon the units and the field strength at the sun's magnetic equator. This will give zero values near the equator and the poles, and maxima near 45° N. and S. The effect of the elliptical polarisation of the coelostat mirrors is to flatten by a negligible amount the curve of displacements. C. P. B.

36. *Origin of Solar Electricity.* **J. A. Harker.** (Roy. Astronom. Soc., M.N. 73. pp. 562–567, June, 1913. Chem. News, 108. pp. 261–263, Nov. 28, 1913.)—The author refers to his experiments on the emission of electricity from carbon inside an electric furnace [see Abstract No. 1417 (1912)].

Positive electricity was emitted at temperatures from 1000° to 1400° C. With those metals which melt within this range a sudden increase in the positive current occurred at the liquefying point. At higher temperatures negative electricity predominates, and its quantity increases rapidly with the temperature.

Applying these facts to the sun, it would suggest that the solar atmosphere is a highly conducting medium. The modern values of its temperature range from 5600° to 6000° abs. It may thus be that in the solar atmosphere there are very large numbers of electrified particles, by the movements of which enormous currents are generated. C. P. B.

37. *Diffraction Phenomena at Solar Eclipses.* **F. Biske.** (Astrophys. Journ. 38. pp. 192–196, Sept., 1913.)—An analysis is made of the conditions during a total solar eclipse to determine if it may be possible for the dark "shadow bands" to be due to diffraction at the moon's limb.

The conclusion is that the phenomenon is not due to diffraction. C. P. B.

38. *Variations of Solar Atmosphere.* **H. Deslandres** and **L. d'Azambuja.** (Comptes Rendus, 157. pp. 413–421, Sept. 1, 1913.)—During the progress of the sun-spot cycle it has been noticed that the various solar phenomena have not been in unison as regards diminution with the gradual disappearance of the spots. In particular the peculiar polar alignments have been very prominent during the last two years. Diagrams are given showing the relation between the visible phenomena during specially selected rotations in 1912 May, 1912 Oct., and 1913 Feb., the latter including a spot with somewhat high latitude suggesting the commencement of the new cycle. While the spots and filaments have been very sparse, the alignment network appears to have persisted throughout, and it may be that this is a permanent feature of the solar atmosphere. C. P. B.

39. *Harmonic Analysis of Wolf's Sun-spot Numbers.* **H. H. Turner.** (Roy. Astronom. Soc., M.N. 73. pp. 549–552, May, 1913.)—The paper is in part a criticism of Kimura's analysis [see Abstract No. 1796 (1913)], and also in continuation of the work noted in Abstract No. 575 (1913). Kimura's paper purported to be a complete identification of a number of periodicities, grouped in periods of 162, 78, 60, and 50 years. Examination of the coefficients of the series used in the analysis leads to the conclusion that their methodical run is merely a consequence of the *regularity* of the series of Wolf's numbers. C. P. B.

40. *Rotation of Jupiter.* **H. E. Lau.** (Astronom. Nachr. No. 4678. Review by A. S. Williams in Observatory, No. 465. pp. 373–375, Sept., 1913.) —The article is a review of a paper by H. E. Lau, giving a summary of observations made at Copenhagen during the 6 years 1905–10 with a 10-in. refractor. A table is given showing the mean values of the drift of the surface material of the planet in different latitudes, combined with the results of two years' observations by H. Struve with the 13-in. Königsburg refractor during 1903–4. All the results were obtained by direct measurement with the micrometer. The reviewer compares these results with those made by various observers during the 20 years 1887–1906. Several discordances are apparent, the chief one being with respect to the Great Equatorial Current, which is shown by the longer series of

results to drift at substantially the same rate throughout its whole breadth, though near its northern border the rate is somewhat slower than that of the current in general. C. P. B.

41. *Energy in Planetary Motions.* **A. Gray.** (Nature, 91. pp. 581–582, Aug. 7, 1913.)—If a particle be brought from infinity by the action of a central attraction varying as the inverse square of the distance to a circular orbit about the centre, or transferred from one circular orbit to another, half only of the potential energy exhausted is represented by the orbital motion, so that half the work must have been expended in overcoming resistance of some sort. The author here states and proves the corresponding theorem in elliptic motion, viz. the time-average of the kinetic energy, taken for one revolution in the orbit, is half of the corresponding time-average of the potential energy exhausted in the passage from infinity to the distance r, with a similar theorem for the difference of energy when the particle is transferred from one orbit to another about the same centre. If the orbit be an hyperbola of which $2a$ represents the distance between the vertices, the kinetic energy at distance r exceeds the potential energy exhausted in the transference from infinity to that distance by the mean kinetic energy of the motion in an ellipse of semi-major axis a. Thus if a planet formed in the course of condensation of a nebula is to have an hyperbolic orbit, it must, by an internal explosion, or some other convulsion or process, have a quantity of kinetic energy given to it in excess of that produced by the transference of the matter from infinite dispersion in space. In the evolution of planets according to the nebular hypothesis hyperbolic orbits would thus be exceptional cases. G. W. DE T.

42. *Motions and Distances of Pleiades and other Star Groups.* **H. C. Plummer.** (Roy. Astronom. Soc., M.N. 78. pp. 492–499, May, 1918.)—An attempt has been made in former papers [Abstract No. 1615 (1913)] to exhibit the general character of the galactic motions of stars of Type I for which radial velocities are known. It has been shown at Mount Wilson that all local groups of stars, for which the necessary data are available, move in space nearly parallel to the Milky Way. Examination has been made of the Pleiades, and of groups of stars in the constellations Vela, Perseus, and Centaurus-Scorpio, with the general result that no large component *normal* to the plane of the Milky Way has been detected.

C. P. B.

43. *Motion of the Stars.* **C. V. L. Charlier.** (Roy. Astronom. Soc., M.N. 78. pp. 486–491, May, 1918.)—Advance notes of a research on the motions of the stars to be published in a future communication from the Lund Observatory. The *true apex* is found to be RA = 278·17° ± 2·06°; Decl. = + 31·15° ± 1·76°, as derived from the proper motions of the stars of fifth magnitude. Using Campbell's value of the solar velocity (20 km. per sec.), the mean parallax of the fifth magnitude stars is 0·01126″ ± 0·00072″. The true vertex does not coincide with the apparent vertex, but the apex, apparent vertex, and true vortex always lie on the same great circle.

C. P. B.

44. *Spectra of Novæ and Pressure Effect.* **W. G. Duffield.** (Roy. Astronom. Soc., M.N. 78. pp. 631–645, June, 1918.)—Dealing with the points of resemblance between the spectra of Novæ and metals under pressure, the

subject is dealt with in regard to the doubling of the lines, their broadening, the intensity curves and structure of the broadened lines, the reversal and relative intensities of the lines. The difficulty of accepting the theory outlined is owing to their being no explanation of the enormous velocities indicated by the displacement of the dark lines. [See Abstract No. 1649 (1899).] C. P. B.

45. *Spectrum of Nova Geminorum* (1912). **A. L. Cortie.** (Roy. Astronom. Soc., M.N. 73. pp. 646–652, June, 1913.)—Photographs of the Nova spectrum were obtained in March and April, 1912, with the Hilger compound prism attached to the 15-in. equatorial refractor, and during the early months of 1913 with a 6-in. objective prism made by Thorp for the 6-in. Dallmeyer portrait lens given to the Observatory by E. T. Whitelow. The details of the spectra are tabulated in comparison with those obtained at Mt. Wilson by Adams and Kohlschütter, showing good agreement. It is concluded that the dark-line enhanced spectrum of March, 1912, became mainly a bright-line spectrum in April. The most prominent feature of the 1913 spectra was the series of bright nebular bands at λλ4069, 4363, 4637, 5007. Other bright lines were present, including enhanced lines of Ti and Sn. This permanence of chromospheric lines suggests that the phenomenon may be due to a chromospheric outburst on a large scale in a nebulous star. C. P. B.

46. *Variable Stars of Cluster Type.* **H. C. Plummer.** (Roy. Astronom. Soc., M.N. 73. pp. 652–660, June, 1913.)—The variable stars which have been found in clusters belong mainly to a certain well-marked type, the most characteristic feature being the extremely short period of variation. Certain of these stars are discussed analytically, and the general possibilities of the various theories advanced for their explanation examined. No very decided conclusion is possible, but it is suggestive that there appears to be some evidence of their being of the spectroscopic binary type. C. P. B.

47. *Orbits of Eclipsing Binaries.* **H. Shapley.** (Astrophys. Journ. 38. pp. 158–174, Sept., 1913.)—A summary is given of numerous publications dealing with the problem of eclipsing binaries [see Abstracts Nos. 880, 947, 1614 (1913)]. Special attention is given to the differences of brightness and size of the components of such systems; in most cases the large faint star has been found to be redder than the brighter component, suggesting that they are of a later spectral type. C. P. B.

48. *Stellar Parallaxes.* **F. Slocum** and **S. A. Mitchell.** (Astrophys. Journ. 38. pp. 1–26, July, 1913.)—Tables are given of a series of parallax determinations on fourteen stars made from photographs taken with the 40-in. refractor of the Yerkes Observatory. C. P. B.

49. *Observations of Variable Star,* 97·1910 *Cygni.* **E. E. Barnard.** (Roy. Astronom. Soc., M.N. 73. pp. 500–518, May, 1913.)—Discovered by Hinks on plates taken in Aug., 1909, this star was at first thought to be a Nova, but later observations now suggest that it is a variable of long period, about nineteen or twenty months, with a range of about six magnitudes in brightness. Details are given of the measurements throughout a long series of comparisons extending to 1913, April 14. C. P. B.

50. *Photographic Star Magnitudes.* (Roy. Astronom. Soc., M.N. 73. pp. 518–524, May, 1913. From the Royal Observatory, Greenwich.)—The

paper deals with the corrections depending on the distance of the star image from the centre of the plate, necessary for determining star magnitudes from photographs taken with the Greenwich Astrographic Equatorial. This is of special importance, as the standard stars of the Harvard sequence fall on a comparatively small area in the centre of the plate. A sensitive method of determining these corrections is afforded by counting the relative numbers of stars photographed in different parts of the plate. It is found that the area of best definition is an annulus, the zone of max. intensity being at 40′ from the axis. C. P. B.

51. *Stellar Photometry with Photoelectric Cell.* **W. F. Schulz.** (Astrophys. Journ. 38. pp. 187–191, Sept., 1913.)—Encouraged by the great sensitiveness obtainable with the photoelectric cell [see Abstracts Nos. 1411 (1912), 1327 (1913)] the author has made experiments with the object of determining the relative intensity of star radiation and detecting any variation of the starlight. The cell used had a Pt-wire anode, with a layer of metallic potassium for the kathode. In Dec., 1912, the light from the star α Aurigæ (Capella) was measured, and in April, 1913, that from α Böotes (Arcturus), using as light collector the 12-in. equatorial of the University of Illinois. With 40 volts on the needle and 160 volts on the cell, the rate of deflection at a scale distance of 2 m. was 20 mm. in 30 secs. With 200 volts on the cell, the rate was 18 mm. in 20 secs. Further experiments are to be made in order to compare the action of the photoelectric cell with that of a selenium cell. C. P. B.

52. *Spectrum of α Canum Venaticorum.* **A. Bélopolsky.** (Astronom. Nachr. No. 4681. Nature, 92. pp. 143–144, Oct. 2, 1913. Abstract. Acad. Sci. St. Pétersbourg, Bull. 12. pp. 689–704, Sept. 15, 1913. Observatory, No. 467. pp. 432–435, Nov., 1913.)—As reported previously [Abstract No. 1638 (1913)], the spectrum of this star shows striking variations of a periodic nature. In the present paper a discussion is given of 67 spectrograms secured in the interval April 15 and June 13, 1913, with the three-prism spectrograph attached to the 30-in. refractor. From measures of the line λ4130·0 he finds a period of 5·50 days. Another set of lines appears to vary inversely with λ4130, while lines of hydrogen, Mg, Ca, and Fe display little change. C. P. B.

53. *Spectrum of Wolf Rayet D.M. + 30·3639°.* **P. W. Merrill.** (Lick Observatory, Bull. No. 230. Nature, 92. p. 109, Sept. 25, 1913. Abstract.)—Results are given of the details in the red end of the spectrum of this interesting star, of photographic magnitude 10·0. In addition to the ordinary Wolf-Rayet lines two others are shown near Hα. C. P. B.

54. *Variation of RU. Camelopardalis.* **H. Shapley.** (Laws Observatory, Bull. No. 21. Nature, 92. p. 86, Sept. 18, 1913. Abstract.)—Discussion of the photometric measures of the star, resulting in the conclusion that the light-variations can be accounted for on the hypothesis of a single, uniformly luminous, ellipsoidal body rotating in a period of 44·344 days. The spectrum of the star is peculiar and apparently variable, possibly belonging to Class N. C. P. B.

55. *Energy of Nebulæ and Carnot's Principle.* **H. Block.** (Comptes Rendus, 157. 101–103, July 15, 1913.)—According to Arrhenius, Carnot's

principle is inapplicable to nebulous gases, since, owing to the attenuated value of gravity, those molecules of high speed will escape from the nebula and form a hotter zone, whereas the nebula, only retaining the molecules of small velocity, will cool down. Schwarzschild (Astrophys. Journ. 37. p. 297, May, 1913) has recently published a very interesting calculation on this point, and arrived at the remarkable result that the escaped portion will possess a lower temperature than the initial temperature of the nebula. The author has taken up the mathematical study of this problem with the object of minutely examining Schwarzschild's calculations, and assumes the velocities of the molecules near the surface to be distributed according to Maxwell's law. Schwarzschild's result is verified. In every case the escaped mass will cool, as also the residue, but the final energy condition is more favourable than the initial since there is a gain in potential energy, and the difference between the temperatures represents a more favourable partition of energy. The ratio of the number of molecules escaping to those which remain is found to be 0·456 : 0·544. A calculation is then made as to the dimensions necessary for a spherical nebula in order that these conditions may be realised, and the radius for the special case of hydrogen at 50° C., is found to be 3250 M, where M is the mass of the nebula in solar units, the unit of length being the radius of the terrestrial orbit. Although the phenomenon pointed out by Arrhenius is not the ability for one part of the nebula to become warm at the expense of the other, there may, under favourable circumstances, be a conversion of considerable quantities of thermal energy into a form more useful. H. H. Ho.

56. *Variable Nebulæ.* **G. Bigourdan.** (Comptes Rendus, 157. pp. 421–423, Sept. 1, 1913.)—The author suggests the more detailed publication of observations of nebulæ, in order to provide material for the detection of any possible variability. Attention is directed to a nebula discovered by Hind in 1845 [G.C. 4473 (NGC. 6760)], which has been suspected of variability, and which Bonelly has recently observed with a telescope of only 0·165 m. aperture. C. P. B.

LIGHT.

57. *New Prism with Curved Faces.* **A. Callier.** (Zeitschr. Instrumentenk. 33. pp. 22–24, Jan., 1913.)—The new prism, designed to avoid the use of lenses in a spectroscope, is a modification of one designed by Féry. In Féry's prism the first face in section is theoretically a logarithmic spiral, replaced in practice by a circular arc. The refracted rays entering the prism undergo internal reflection at a second face, and then emerge again at the same face through which they entered, the curvature of the reflecting face being so calculated that a real image of the slit is finally formed close to the original source. This prism suffers from the following disadvantages: (1) There is generally considerable loss of light by reflection. (2) The image and the source being in proximity, the deviation is not minimum, and the definition suffers. (3) Since the rays enter and emerge at the same face, there can be no magnification of the spectrum. In the new prism, devised to overcome those defects, three faces come into play, the first and third, where the rays enter and emerge respectively, being both theoretically in section arcs of logarithmic spirals, while the second face where the rays are reflected internally is an elliptic arc, one focus of which is the virtual image of the source in the first face, the other focus the corresponding point for the final image and third face. In this arrangement the reflection is total, and the deviation minimum, and by giving different curvatures to the first and third faces, the spectrum can be magnified or diminished. The firm Adam Hilger, Ltd., at the author's request, undertook some experiments with the new prism, the theoretical surfaces being replaced in practice by spherical ones. The definition was found to be satisfactory, but there was considerable astigmatism, as in the case of the concave grating, and Fèry's prism. A spectrogram of the copper arc taken with it is reproduced in the original article. A. E.

58. *Plane Grating for Stellar Spectroscopy.* **J. S. Plaskett.** (Astrophys. Journ. 37. pp. 373–379, June, 1913.)—Previous investigations on the performance of grating spectrographs on stellar spectra have been made by Poor and Mitchell, and Wadsworth [see Abstract No. 612 (1898)], but the method has not been generally adopted owing, probably, to the loss of light in the various orders. Efforts have been made at various times to produce gratings having a greater portion of the light concentrated in some one spectrum, and in such cases it might be possible to construct a spectrograph of high efficiency compared to the three-prism spectrographs, where the long path through dense flint results in much absorption of the violet radiation. A grating has been obtained, ruled by Anderson, of Johns Hopkins University, having ruled surface 7·4 × 9·4 cm., 15,000 lines to the inch, which is estimated to diffract about 50 % of the light returned by the speculum metal surface into one first order. Tests were made on stellar and solar spectra with grating and prism spectrographs of about equal dispersion. One of the most striking features of the grating spectra is the comparative uniformity in intensity between Hβ and λ3850. The weakness of the spectra will be a disadvantage unless the concentration of light in one order can be still further increased, but the system should be of service where spectra down to the K line (λ3933) are required. C. P. B.

59. *Absolute Measurement of Ultra-violet and Visible Radiations.* **C. Winther.** (Zeitschr. Elektrochem. 19. pp. 389–397, May 1, 1913.)—The instrument, the fluorometer, consists of a glass box, 5 cm. long, filled with a very dilute solution of some fluorescent material (rhodamine, sodium fluorescein known as uranin, quinine sulphate). To the right is the standard lamp, a 16-c.p. Osram lamp with simple loop; to the left the light to be tested. Two beams of light enter through stops, from the right and the left, and form two parallel fluorescent light-bands, the intensity in each band decreasing from the entrance to the opposite wall. By means of a sliding lens and a cross-wire attached to the top of the box the position is determined at which the intensities of the two bands are equal. This measurement, together with the known extinction coefficients for the respective wave-lengths, gives the required energy. The extinction coefficients were determined with the aid of monochromatic light (Hilger quartz spectrograph) and a potassium photo-electric cell (of Elster and Geitel); the calibration in absolute units was done by E. S. Johansen. The author tests various light filters with his fluorometer, studies the energy distribution in spectra, and recommends his instrument, which is supplied by the Aktieselsk. Dansk Telegrafonfabrik, of Copenhagen, also for the determination of reaction velocities. H. B.

60. *Correction of Field of Newtonian Telescope.* **R. A. Sampson.** (Roy. Astronom. Soc., M.N. 73. pp. 524–527, May, 1913.)—The paper deals with a proposed method of correcting the geometrical defects of the Newtonian reflector by the interposition of three thin lenses of the same kind of glass. C. P. B.

61. *Refraction and Dispersion of Gaseous Nitrogen Peroxide.* **C. Cuthbertson** and **M. Cuthbertson.** (Roy. Soc., Proc. Ser. A. 89. pp. 361–369, Nov. 1, 1913.)—By means of a Jamin's refractometer, the refractivity of pure NO_2 for $\lambda = 6438$, reduced to standard conditions by the formula $(\mu - 1)^{0\cdot76} = N\lambda/L \cdot t/273 \cdot 76/p$, is found to be approximately 0·000509. That of pure N_2O_4 is 0·001123, so that the effect of polymerisation is to increase the refractivity by about 10·5 per cent. The refractivity of a molecule of NO_2 is greater than those of its constituent elements by 21 per cent. The dispersive power of a molecule of NO_2 in the red and green is considerably greater than that of a molecule of N_2O_4. T. H. P.

62. *Electric and Magnetic Double Refraction.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 215–220, 1913.)—Mathematical discussion concluding with a result in agreement with Sommerfeld's derived from consideration of the emission of a system of electrons in a magnetic field. [See Abstracts Nos. 800 and 1151 (1913).] E. H. B.

63. *Propagation of a Luminous Signal in a Dispersive Medium.* **L. Brillouin.** (Comptes Rendus, 157. pp. 914–916, Nov. 17, 1913.)—A mathematical investigation employing Fourier's integrals. The author finds that the velocity of the signal is assimilated to that of the group for all signals whose periods correspond to a normal dispersion. The values of the two velocities differ in the region of anomalous dispersion. The velocity of the signal is always lower than that of light *in vacuo.* E. H. B.

64. *Fresnel's Diffraction Phenomena.* **W. Arkadiew.** (Phys. Zeitschr. 14. pp. 832–835, Sept. 1, 1913.)—Gives a number of photographs representing

diffraction phenomena as studied from the time of Grimaldi and Fresnel down to the eighties, when the new form of Huyghen's principle presented by Kirchhoff inaugurated a new era. The source used is a slit 1 mm. wide, and the photographic plate was at a distance of 39 m. from the object casting a shadow. E. E. F.

65. *Interferometer in Rotation demonstrates a Relative Ether Wind.* **G. Sagnac.** (Comptes Rendus, 157. pp. 708–710, Oct. 27, 1913.)—In this experimental research a horizontal plate 50 cm. in diameter rotates uniformly about a vertical axis N times (once or twice) per sec. This plate carries the various parts of an interferometer, *including the source of light* (an electric lamp) and the *receiver* (a fine-grained photographic plate), which records the interference bands at the focus of a lens. The two interfering pencils, reflected by four mirrors, are superposed in inverse senses round the same horizontal circuit enclosing a certain area S. On the photographs *d* and *s*, obtained respectively during a *dexter* or *sinister* rotation of the plate at the same rate, the centre of the central fringe shows two positions. This displacement, z, of the system of bands is then measured. The author derives the relation $z = 16\pi NS/\lambda V_0$, where λ is wave-length of the light used and V_0 the speed of light in vacuum. For the indigo light used, $N = 2$ per sec., $S = 860$ cm.^{2}, z was 0·07 cm. and showed well with bands under 1 mm. wide, E. H. B.

66. *Constancy of the Velocity of Light.* **E. Freundlich.** (Phys. Zeitschr. 14. pp. 835–838, Sept. 1, 1913.)—A reply to de Sitter's alleged proof [Abstract No. 1418 (1913)] of the constancy of the velocity of light from considerations of double-star orbits. He admits that observations speak at all events against the velocity of the source being simply added to the ordinary velocity of light, but some fraction of it might be added. The discrimination of such an addition would be difficult, especially as each observer takes Kepler's laws for granted and seeks to range his observations into a curve which fits them best. But it is notorious that many binaries show an eccentricity which is directed in the line of sight in a manner quite inconsistent with a fortuitous orientation of orbits. Miller Bar enumerates 23 systems out of 28 taken at random, and 7 out of 8 with an eccentricity greater than 0·5. Certain disturbances in the velocity of revolution, hitherto attributed to perturbation by a third body, may be due to inconstancy of the velocity of light. Spectroscopic binaries of accurately known parallax are the most promising material, but at present the question is still open. [See also Abstract No. 884 (1910).] E. E. F.

67. *Pressure of Radiation on Small Reflecting Sphere.* **J. Proudman.** (Roy. Astronom. Soc., M.N. 73. pp. 535–539, May, 1913.)—The previous discussions of this problem by Schwarzschild and Nicholson are not in complete agreement [see Abstract No. 1108 (1910)], and the problem has again been worked through by the present writer. His new results are in substantial agreement with those of Nicholson, except with regard to the max. pressure, and the details concerning this maximum are included in this paper. C. P. B.

68. *Doppler Principle and Relativity.* **K. Tamaki.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 215–234, May, 1913.)—A theoretical treatment which may be summarised as follows:—The Doppler-effect due to the motion of an

observer and a light source is calculated in the usual manner. As is well known, the results of the two cases are different. The assumptions tacitly made in the usual calculation are pointed out.

Rejecting one of the assumptions and trying to harmonise the result with the first postulate of the principle of relativity as to the change of frequency in the two cases, it is shown that one of the three following hypotheses must be introduced: (i) The *emission* hypothesis, which states that the velocity of light from a moving source is $c + v$, v being the velocity of the source and c that of light when the source is at rest. (ii) The *frequency* hypothesis, which states that the frequency of light-waves emitted by a moving source is $n = n_0 [1 + (v/c)^2]$, where n_0 is the frequency of light when the source is stationary, c and v having the same meanings as in (i). (iii) The *different-units* hypothesis which states that between the units of time T_s and T_m adopted by a stationary observer and a moving one there is the relation—

$$T_m = T_s \,.\, 1/\sqrt{1-(v/c)^2}.$$

It is proved that the first hypothesis must be rejected when we consider the change of wave-length, and the second hypothesis when the case of the Doppler-effect due to a moving mirror is considered. Thus it is concluded that the first and second postulates of Einstein's Principle of Relativity are in no conflict. The change of length due to motion is shown to follow from that of the unit of time. The Lorentz-Einstein transformation equations are derived most simply from the first postulate and the change of length. [See Abstract No. 2277 (1905).] E. H. B.

69. *Objective Photometry.* **W. E.** and **R. Pauli.** (Ann. der Physik, 41. 4. pp. 812–828, July 17, 1913.)—Reference is made to Langley's researches on coloured light, the results of which are criticised on several grounds, notably the fact that the lights were compared on an acuteness-of-vision basis. The authors describe researches comparing red and green light with a lens-flicker photometer. The methods of obtaining approximately pure red and green light are described, and the absorption curves of various filters given. Bolometric tests of the corresponding energy values were also undertaken. The authors reach the conclusion that the eye (bright adapted) is 960 times as sensitive to green light (546 $\mu\mu$) as to red light (660 $\mu\mu$). But the result is affected by the state of adaptation of the eye. For dark adaptation the corresponding ratio was 1640, for central vision 590. The authors also experimented with mixtures of light. They point out that it is possible to have two equally luminous fields of exactly the same colour and saturation, but the energy required to produce a given brightness may be widely different. For these reasons objective photometry, which avoids the complexities of the eye, is impracticable. J. S. D.

70. *Absorption of Light by Inorganic Salts.* IX. *Solutions of Copper, Nickel, and Cobalt Salts in Alcohol and in Acetone.* **R. A. Houstoun** and **A. H. Gray.** (Roy. Soc. Edinburgh, Proc. 33. pp. 137–146, 1912–1913.)—When copper, nickel, and cobalt salts are dissolved in alcohol or acetone their absorption is much greater, and also more characteristic of the molecule, than when they are dissolved in water. The addition of water to alcoholic solutions of copper chloride produced a small initial increase of absorption, followed by a large and progressive decrease. In the case of copper bromide,

the addition of a single drop of water to 8 c.cm. of the alcoholic solution reduced the absorption coefficient almost to its value for solutions in water. Solutions of anhydrous cobalt bromide in alcohol showed a progressive decrease of absorption of light of wave-length $\lambda = 628\,\mu\mu$ as the colour changed from blue to pink by the addition of water. Curves for three concentrations would intersect at abs. coefft. $A = 215$ if extrapolated to concentration $-0{\cdot}4\,\%$ water; it was assumed that this represented the quantity of water originally present in the alcohol. Application of the law of mass-action on the assumption that $A = 215$ in anhydrous alcohol gave values ranging from 6·1 to 9·2 for the number of water-molecules which must be assumed to combine with the salt in producing the change of colour: it is therefore suggested that this change is probably due to the conversion of the anhydrous salt into the known hexahydrate. T. M. L.

71. *Absorption of Light by Inorganic Salts.* X. **R. A. Houstoun** and **C. Cochrane.** (Roy. Soc., Edinburgh, Proc. 33. pp. 147–155, 1912–1913.)—(1) The acetate and sulphate give similar absorption curves in the case of cobalt and nickel, but not in the case of copper, of which the acetate gives a much greater absorption in the red. It is suggested that copper acetate may have a different chemical constitution. (2) Ionisation has nothing to do with the colour-changes of cobalt, nickel, copper, and iron salts. The molecular extinction coefficients are only changed to any large extent at certain "sensitive-points" of the spectrum. Of these points, the molecular extinction-coefficients are constant at low concentrations and increase asymptotically as saturation is reached; this is quite different to the behaviour of the coefficients of ionisation, so that there is no connection between the two quantities. (3) The effect of adding water to an alcoholic solution of cobalt chloride has been shown (in Part VI) to be attributable to the formation of a hydrate. Solutions in acetone give a similar absorption-curve, but the effect of adding water is quantitatively very different. It is suggested that the anhydrous salt combines with the acetone. (4) The abnormal behaviour of cobalt and nickel iodides is due to formation of oxyiodides with liberation of iodine.

T. M. L.

72. *Absorption of Light by Inorganic Salts.* XI. *Conclusion.* **R. A. Houstoun.** (Roy. Soc. Edinburgh, Proc. 33. pp. 156–165, 1912–1913.)—The absorption spectra of aqueous salt-solutions appear to be influenced very little by the linkage between the positive and negative radicals. The view is advanced that the three bands characteristic of the nickel salts and the two bands characteristic of the cobalt salt are due to the association of the metallic radicals with a watery atmosphere, which is only slightly affected when ionisation occurs.

Attempts to apply electronic theories have met with but little success. Only in the case of water has a dynamical model been invented which satisfies the experimental observations by giving a ratio 2·32 for the ratio of wave-lengths of two bands instead of 2·00, and 7110 or 1550 for the value of e/m instead of 9660.

Theoretical generalisations are difficult, in part because they must cover so wide a range, *e.g.* values of A, the extinction coefficient, ranging from 27,000 to 0·01 and wave-lengths from $0{\cdot}23\,\mu$ to $1{\cdot}8\,\mu$. T. M. L

73. *Wood's Method of Discovering Spectrum Laws.* **A. Afanassieff** and **D. Roschdestwensky.** (Phys. Zeitschr. 14. pp. 780–783, Aug. 15, 1913.)—

Describes a new modification of this method [Abstract No. 1662 (1913)]. White light from an arc lamp falls upon the vertical slit of an echelon grating of 1 cm. step and 1 mm. width. The diffraction pattern is thrown upon the narrow vertical slit of an auto-collimating grating spectrograph. This yields fine vertical bright lines, whose distance apart depends upon the echelon constant. On placing the echelon with its slit horizontal, the lines are slightly inclined. By widening the slit of the spectrograph symmetrically, each of the inclined lines may be drawn out into a strip in a horizontal direction, and the strips remain separated by dark lines. Each of these strips represents a piece of spectrum in the echelon dispersion, and any regularities are at once evident by a curve or pattern in the whole trace. The regularities are well illustrated by the absorption spectrum of iodine. E. E. F.

74. *Absorption Bands of Acetone.* **J. Stark.** (Phys. Zeitschr. 14. pp. 845–847, Sept. 1, 1913.)—Shows that if there is a point of inversion in an absorption curve, it indicates the existence of a feeble band within the wave-length area of the principal band. Both the work of Gelbke and that of Bielecki and Henri [Abstract No. 1819 (1913)] indicate that acetone has, besides the short-wave band, a much less intense ultra-violet absorption band of a wave-length above 330 μμ. E. E. F.

75. *Arc and Spark Spectrum o, Oxygen Canal Rays.* **J. Stark, G. Wendt,** and **H. Kirschbaum.** (Phys. Zeitschr. 14. pp. 770–779, Aug. 15, 1913.)—The authors study the question whether the ratio of the intensities of the arc and spark lines of oxygen changes with the kathode-fall producing the canal rays; also, whether there are several distinct speeds of canal rays, indicating different valencies. The results show that on increasing the kathode-fall from 3200 volts to 15,000 volts the stationary and the moving intensities of the spark lines increase considerably, whereas the series lines almost disappear. The spark lines 4190·0 Å. and 4076·2 Å. show distinct traces of a point of inflection in the intensities of their motion spectra, indicating three distinct velocities. Further evidence is adduced for the existence of two distinct types of spark lines, one of which is sharp, while the other is diffuse. The latter represents a valency one unit higher that the former. The authors also distinguish two distinct arc spectra, and believe that the bearer of one of these is the positive univalent O_2-molecule. E. E. F.

76. *Ultra-violet Spark Spectra of Metals.* **J. M. Eder.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 607–633, March, 1913. Zeitschr. wiss. Phot. 13. 1. pp. 20–40, Nov., 1913.)—Describes wave-length measurements, in international units, of the ultra-violet spark spectra of the following metals: Ag, Al, As, Au, Ba, Bi, C, Ca, Cd, Cu, Pb, Sb, Sn, Sr, Tl, Zn. Wave-length tables are given. A. W.

77. *Crossed Spectra obtained by Combinations of Different Interferometers.* **H. Nagaoka** and **T. Takamine.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 141–150, Oct., 1913. Phil. Mag. 27. pp. 126–136, Jan., 1914.)—The method of crossed spectra introduced by Kundt was utilised by Gehrcke and v. Baeyer for discriminating "ghosts" by means of interference points produced by Lummer-Gehrcke plates placed at right angles to each other. This method can be applied to combinations of different interferometers, and the crossed spectra thus obtained may sometimes be utilised for the purpose of accurately determining differences of wave-lengths. The following combinations were tried: (i) a plane grating crossed with an echelon, (ii) an

echelon with another echelon, (iii) a Lummer-Gehrcke plate with a Fabry-Perot air plate, (iv) Fabry-Perot air plate with an echelon, and (v) an echelon with a Lummer-Gehrcke plate. The first way of crossing was not effective on account of the low resolving power of the grating; the second, though somewhat better, was not at all comparable with the advantages that can be gained by the last three methods of combination. These last three are discussed in detail, reference being made to the structure of certain mercury lines. A. W.

78. *Arc and Spark Spectra of Aluminium.* **R. Grünter.** (Zeitschr. wiss. Phot. 13. 1. pp. 1–19, Nov., 1913.)—After a brief review of previous work on the spectrum of aluminium a detailed account is given of measurements of wave-lengths, in international units, in both the arc and spark spectra of the metal. The results are discussed with reference to Deslandres' laws. A table is also given of the wave-lengths of a number of bands, the results of Exner and Haschek, and those of Hasselberg being given for comparison. A. W.

79. *Arc Spectra of Certain Metals below* $\lambda = 3200$. **W. Huppers.** (Zeitschr. wiss. Phot. 13. 2. pp. 46–88, Nov., 1913.)—A quartz spectrograph was employed and lines of wave-lengths below λ3200 were re-measured in the spectra of Zn, Pb, Ca, Tl, Cd, Mg, Al, Cu, Ag, Li. Hartmann's formula was used for determining the wave-lengths of the lines. A large number of hitherto unknown lines were measured. Of these new lines some can be interpreted as series or combination lines. There is still, however, some uncertainty about the series lines of Ag and Cu. A. W.

80. *Wave-lengths of Iron Spectrum Lines.* **K. Burns.** (Lick Observatory Bull. No. 238. Nature, 92. p. 144, Oct. 2, 1913. Abstract.)—A series of determinations have been made at Marseilles, in the laboratory of Buisson and Fabry, of the standard iron spectrum lines between λ5434 and λ8824. Attention is drawn to the varying wave-lengths of arc lines depending on the location, in the arc, of the part examined by the spectrograph. C. P. B.

81. *Pressure-shift of Iron Lines.* **H. G. Gale** and **W. S. Adams.** (Astrophys. Journ. 37. pp. 391–394, June, 1913.)—In the course of a former investigation [Abstract No. 491 (1912)] it was found that for a pressure of 8 atmos. most of the lines could be classified into groups according to the amount of their pressure-shifts. The present work gives the results of examining the pressure-shifts of the lines which become very diffuse at high pressures, including the new group found by St. John and Ware in 1912 [Abstract No. 1699 (1912)]. The spectra were obtained at pressures varying from 5 or 10 cm. to 1 or 2 atmos., so that the lines should be more easily measurable. Observations have been made on about 180 lines in the region between λ4800 and λ5700, and a table is given showing the detailed results, including the lines exhibiting shift to the violet with increasing pressures. C. P. B.

82. *Behaviour of Spectrum Lines with Satellites in a Magnetic Field.* **W. Voigt.** (Ann. d. Physik, 42. 4. pp. 815–824, Nov. 4, 1913.)—A mathematical treatment based on the electron theory of absorption and dispersion. A. W.

83. *Anomalous Effect with X-rays.* **F. R. Gorton.** (Science, 38. pp. 547–548, Oct. 17, 1913.)—A sensitive plate is placed film downwards on a silver coin, and a second silver coin so placed above the plate that areas of contact

of the plate and coins partially overlap; the plate and coins are enclosed in a light-tight box and exposed to X-rays from above. When the plate is developed the result is, of course, a light area with but little effect due to radiation transmitted by the upper coin and a dark area due to secondary radiations from the coin below. The anomaly appears at the area of overlapping coins. Since this receives its impression both from the transmitted rays and from the secondary rays from the coin below, it is to be expected that this area will be darker than the remaining area shaded by the upper coin. The opposite is found to be true. With small plates of Pb the effect is reversed, although Au and Cu give the same effect. E. M.

84. *Absorption of Characteristic X-rays by Gases and Vapours.* **R. C. Gowdy.** (Journ. de Physique, 3. Ser. 5. pp. 622–629, Aug., 1913.)—The rays from an X-ray bulb were allowed to fall on a radiator, and the characteristic radiation emitted was measured after passage through a long chamber which could be evacuated or filled with the gas under observation. Tables are given of the absorption coefficients of the radiations of Fe, Ni, Cu, Zn, and As in Au, O_2, N_2, CO_2, H_2, H_2S, C_2H_2, CS_2, $C_4H_{10}O$, $(CH_3)_2CO$, $CHCl_3$, C_2H_5I, C_2H_5Br, and Al. The coefficients of absorption of any two radiations were found to be approximately in the same ratio for any of the gases examined. With regard to As and Zn, however, for gases containing elements of higher atomic weight than 27, the Zn radiation has the larger coefficient of absorption, while for the other gases the reverse holds. This result appears to show that As emits a soft radiation capable of exciting characteristic rays in elements of atomic weight less than that of Al. E. M.

85. *Transmission of X-rays through Fibrous, Lamellar, and Granular Substances.* **S. Nishikawa** and **S. Ono.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 131–138, Sept., 1913.)—With the usual Friedrich and Knipping arrangement the photographs obtained with fibrous asbestos placed normal to the X-ray beam show a set of nearly straight bands passing through the central spot. Of these bands the one in a direction perpendicular to the axes of the fibres is especially conspicuous. If the plane of the asbestos is inclined to the normal, the symmetry of the figure with respect to the principal band is lost. The phenomena can be satisfactorily explained on the assumption that the specimen consists of a number of elementary crystals of a definite prismatic structure arranged parallel to the fibre, and otherwise quite indefinitely, and that each face of elementary crystals gives rise to reflection when a beam of X-rays falls upon it. Organic fibres such as silk, wood, bamboo, show the same effects, although negative results were obtained with quartz fibres and glass wool. Lamellar substances such as talc and mica gave a series of bands radiating from the central spot. With granular substances such as marble, fine powders of rock-salt, quartz, carborundum, etc., photographs were obtained in which the central spot is surrounded by innumerable small spots of which the intensity is a maximum at a certain distance from the centre. In experiments with rolled and annealed metal-foils results were obtained similar to those of Keene [Abstract No. 1965 (1913)]. E. M.

86. *Reflection of X-rays by Crystals.* II. **W. H. Bragg.** (Roy. Soc., Proc. Ser. A. 89. pp. 246–248, Sept. 22, 1913.)—In a previous paper by the author and W. L. Bragg it was shown that the wave-length of a homogeneous beam of X-rays can be found accurately in terms of the spacing of the

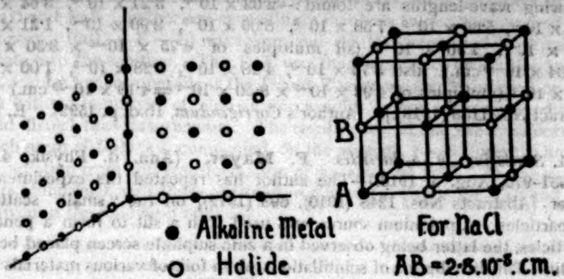
elements of a crystal [Abstract No. 1880 (1913)]. From more recent work [see next Abstract], it appears that reflection phenomena lead to definite knowledge of crystal structure, and various quantitative determinations may now be completed. The elementary volume in rock-salt is a cube with 1 atom of Na at each of four corners, with 1 atom of Cl at each of the other four. In other words, the number of elementary volumes in any space of measurable dimensions is equal to the number of atoms in that space. Assuming the mass of a hydrogen atom to be $1{\cdot}64 \times 10^{-24}$ and the density of rock-salt $2{\cdot}15$, the number of atoms or elementary cubes per cm.^3 is calculated to be $4{\cdot}48 \times 10^{22}$. The edge of the cube is thus 2.81×10^{-8} cm., and this is thus the distance between consecutive reflecting planes parallel to (1.0.0.). The principal bundle of X-rays from a Pt antikathode is found to be a doublet with two sets whose wave-lengths differ from each other by less than 2 per cent. of either. The average glancing angle of reflection is 11·8°. This gives a wave-length

$$=(2d \sin \theta) = 2 \times 2{\cdot}81 \times 10^{-8} \times 0{\cdot}196 = 1{\cdot}10 \times 10^{-8}.$$

A bulb having a Ni antikathode gives one weak beam of homogeneous rays reflected at a glancing angle of 17·2°; the corresponding wave-length is $1{\cdot}66 \times 10^{-8}$. A tungsten antikathode gives a beam at an angle of 12·9°, and the wave-length is therefore $1{\cdot}25 \times 10^{-8}$. On the basis of existing theories certain numerical relations might be expected to subsist between these quantities. In the first place, the "quantum" energy for a wave-length $1{\cdot}10 \times 10^{-8}$ is $h\nu = 1{\cdot}78 \times 10^{-8}$ erg. From Whiddington's results the energy of the kathode ray required to excite the X-ray of the L series in Pt is $2{\cdot}14 \times 10^{-8}$ erg. These numbers are in very satisfactory agreement, and it is also shown that the absorption coefficient of the radiation in question is almost exactly that of the excited L radiation in Pt. A comparison of the different metals examined shows, further, that the frequency of the radiation is very nearly proportional to the energy of the kathode ray required for its excitation. E. M.

87. *Structure of Some Crystals as indicated by their Diffraction of X-rays.* **W. L. Bragg.** (Roy. Soc., Proc. Ser. A. 89. pp. 248–277, Sept. 22, 1913.)—The author advances two methods by which X-rays may be made to help to a determination of crystal structure. The first is based on the Laue photograph and implies the reference of each spot on the photograph to its proper reflecting plane within the crystal. It then yields information as to the positions of these planes and the relative number of atoms which they contain. Thus the more important planes of the crystal system are those densely packed with points of its space lattice, and from this fact it follows that these planes contain rows along which the points are closely packed. The author compares the patterns obtained by passing X-rays through NaCl, KCl, KBr, and KI. For KCl the patterns are simple, having spots of nearly equal intensity, while KBr and KI give modified patterns. If the molecules in each case were at the points of the space lattice, then, as the crystals are similar, the patterns ought to be the same for each substance. Assuming, however, that the atoms are placed at the points of the lattice and that the weight of an atom in the main defines its effectiveness as a diffracting centre, the results are simply explained. In the case of KCl the atoms of K and Cl have nearly the same weight; hence the simple pattern. In the case of KBr and KI the whole diffraction will practically be due to the heavy Br

and I atoms. Thus the effective "planes" in which the X-rays producing the spots are reflected will be different for KBr and KI to those for KCl. The author shows that the results can be quantitatively explained in this way, and thus the following structure is obtained.



The results are verified and extended to other crystals by measuring the glancing angle at which one of the homogeneous beams of X-rays from a Pt kathode is reflected from various faces of a crystal. It has previously been shown that from these measurements the distance *d* between successive reflecting planes can be obtained [$n\lambda = 2d \sin \theta$; Abstract No. 1158 (1913)]. From this the positions of the heavier atoms can be estimated. Further evidence is thrown upon the crystal structure by the results of the relative intensities of the reflected beams of homogeneous radiation in the different orders, this evidence giving the positions of the lighter atoms. E. M.

88. *X-ray Interference Maxima.* **G. Wulff** and **N. Uspenski.** (Phys. Zeitschr. 14. pp. 783–785, Aug. 15, 1913.)—Some observers have found a striation of the interference maxima obtained by grazing reflection from a crystal face, and have been inclined to regard these striations as spectrum lines or interference spectra of different orders. They are, however, open to a simple explanation. They are produced by slight faults in the flatness of the crystalline cleavage plane used. The individual crystals are slightly inclined to each other, and the striation may show a very varying aspect, but all the striæ must lie on ellipses having a common vertex on the primary beam. The order of magnitude assigned to X-rays by M. Laue cannot be controverted by arguments based on these striations. E. E. F.

89. *Interference of X-rays.* **G. Wulff** and **N. Uspenski.** (Phys. Zeitschr. 14. pp. 785–787, Aug. 15, 1913.)—It was shown by G. Wulff [Abstract No. 1157 (1913)] that the X-ray interference maxima may contain an harmonic series of waves, half whose fundamental length equals the projection of the thickness of layer of the space lattice upon the direction of the primary beam. This is confirmed by observations on further reflections of these maxima by means of a second crystal. E. E. F.

90. *Three-fold Symmetry of Röntgen-ray Photographs from Regular Crystals.* **M. Laue.** (Ann. d. Physik, 42. 2. pp. 397–414, Sept. 23, 1913.)—Instead of the four-fold symmetry previously worked out theoretically and with which certain photographs of the interference phenomena agreed, the author now

follows out mathematically the theory of a three-fold (*dreizählig*) symmetry of these phenomena. He is thus led to the conclusion that the points in the photographs are not all due to commensurate wave-lengths, but that a certain spectral law holds. In one such analysis of the experimental results the following wave-lengths are found:—$2·02 \times 10^{-9}$, $3·24 \times 10^{-9}$, $3·64 \times 10^{-9}$, $4·85 \times 10^{-9}$, $5·66 \times 10^{-9}$, $7·68 \times 10^{-9}$, $8·09 \times 10^{-9}$, $8·90 \times 10^{-9}$, $1·21 \times 10^{-8}$, $1·53 \times 10^{-8}$, $2·30 \times 10^{-8}$ (all multiples of $4·75 \times 10^{-8} \times 8·50 \times 10^{-8}$. $= 4·04 \times 10^{-10}$ cm.), also $3·76 \times 10^{-9}$, $4·18 \times 10^{-9}$, $6·28 \times 10^{-9}$, $1·00 \times 10^{-8}$, $1·38 \times 10^{-8}$ (multiples of $4·92 \times 10^{-8} \times 8·50 \times 10^{-8} = 4·18 \times 10^{-10}$ cm.) [See Abstract No. 1153 (1913).]. (Author's *Corrigendum*, Ibid. p. 1592). E. H. B.

91. *Scattering of α-Particles.* **F. Mayer.** (Ann. d. Physik, 41. 5. pp. 931–970, Aug. 5, 1913.)—The author has repeated the experiments of Geiger [Abstracts Nos. 1248 (1910), 698 (1912)] on the "small" scattering of α-particles. A polonium source was used with a slit to form a pencil of α-particles, the latter being observed in a zinc sulphide screen placed beyond the slit. The distribution of scintillations when foils of various materials were placed between the slit and screen was observed, and the mean angle of scattering deduced. The results were found to be in agreement with those of Geiger, and by substituting in Rutherford's formula for compound scattering [Abstract No. 1347 (1911)] the number of electrons in the atom is calculated to be between the atomic weight and half the atomic weight. Observations of the scattered α-particles were also obtained by counting the "grains" on a photographic plate rendered capable of development [see Abstract No. 922 (1910)]. The variation of scattering by a given foil between ordinary temperature and about 400° C. was also investigated, but no change could be observed. E. M.

92. *Magnetic Deflection of Rubidium Rays.* **K. Bergwitz.** (Phys. Zeitschr. 14. pp. 655–658, July 15, 1913.)—Shows that rubidium rays are β-rays of velocity about $1·8 \times 10^{10}$ cm./sec. This agrees with the failure to trace an α-radiation by scintillation or heat effects (Büchner, Henriot). E. E. F.

93. *Scattering of Particles of Matter with β-Rays.* **M. Levitska.** (Russian Physico-Chemical Soc., Journ. 44. 3. pp. 81–97, 1912.)—Rutherford's conclusion is that Crowther's determination of $\phi/\sqrt{t}$ enables a correct calculation of Ne to be made as follows:—

Element.	Weight of Atoms.	N.
Aluminium	27	22
Copper	63·2	42
Silver	108	78
Platinum	194	138

The numbers of electrons are, however, altogether different to those given by Thomson, while Wilson's differ from both. This problem of scattering cannot, therefore, as yet be considered as satisfactorily solved. I. P.

94. *Analysis of the γ-Rays from Radium D and Radium E.* **E. Rutherford and H. Richardson.** (Phil. Mag. 26. pp. 324–332, Aug., 1913.)

—In a previous paper [Abstract No. 1675 (1913)] the authors have given results of the analysis of the γ-radiation from RaB and RaC. In the present paper the γ-radiation from RaD and RaE has been examined by a similar method. These radio-active substances are of unusual interest in considering the problem of the connection between β- and γ-rays, since the γ-rays emitted by RaD and RaE together are exceedingly feeble in intensity compared with the β-rays. Ra(D + E + F) was taken, and the RaF separated by dipping a Cu plate into the solution. The RaE was then separated by dipping in a Ni plate, and by further operations the D and E were separately isolated on filter paper without impurities of high atomic weight, so that no excited radiations should disturb the measurements. The results showed that the transformation of each atom of RaD is accompanied, on the average, by 50 times the amount of γ-radiation from the transformation of an atom of RaE. The absorption results, combined with those obtained in a previous paper for RaB and RaC, are given in the following table :—

	Absorption Coefficient μ in Aluminium.	Mass Absorption Coefficient μ/D in Aluminium.
RaB	230 (cm.)$^{-1}$	85 (cm.)$^{-1}$
	40 „	14·7 „
	0·51 „	0·188 „
RaC	0·115 „	0·0424 „
RaD	45 „	16·5 „
	0·99 „	0·36 „
RaE	Nearly the same types of radiation as from RaD, but relatively very feeble.	

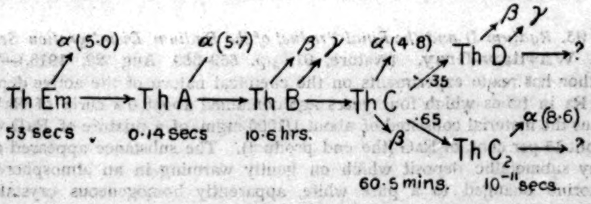
The soft type of radiation $\mu = 45$ from RaD and RaE corresponds to the characteristic X radiation of series L from an element of at. wt. 210, *i.e.* the atomic weight calculated on the disintegration theory. E. M.

95. *Radium D and the Final Product of the Radium Disintegration Series.* **R. Whytlaw-Gray.** (Nature, 91. pp. 659–660, Aug. 28, 1913.)—The author has made experiments on the chemical nature of the active deposit of Ra in tubes which four years ago contained about 0·2 curie of RaEm. Thus the material consisted of about 1/1000 mgm. of a mixture of RaD with about 15 per cent. of RaG (the end product). The substance appeared as a grey submetallic deposit which on gently warming in an atmosphere of chlorine changed to a pure white, apparently homogeneous crystalline chloride. On heating *in vacuo* to 220° C. none of the material was evaporated. The chloride was dissolved in water and tested for lead by Behren's method, viz., by the formation of a characteristically crystalline triple nitrite with the nitrites of copper and potassium. The results showed that it is probable that both RaD and RaG form the triple nitrite identical with that formed by lead. Thus the investigation tends to support the theories of Soddy, Russell, and Fajans, that elements can exist chemically identical but differing from one another by a few units in atomic weight. E. M.

96. *Radiation of Radium at the Temperature of Liquid Hydrogen.* **Mme. P. Curie and H. Kamerlingh Onnes.** (Konink. Akad. Wetensch.

Amsterdam, Proc. 15. pp. 1430–1441, July 15, 1913. Communication No. 135 from the Phys. Lab., Leiden. Le Radium, 10. pp. 181–186, June, 1913.)—The experiments were made on the penetrating γ-rays from Ra in equilibrium with its products (to RaC). The tube containing the Ra was placed in a copper test-tube just fitting into a vacuum test-tube into which liquid hydrogen could be poured. The tubes were surrounded by an airtight ionisation vessel, the thickness being sufficient to cut off β-rays. The ionisation was balanced by an ionisation current in a secondary chamber due to γ-rays from a secondary radium preparation. Liquid hydrogen was then poured in and a change in the balance looked for. Only a few experiments could be made, and the authors state that it would have been desirable to have made a greater number and to continue these during a greater length of time. Nevertheless the results show that cooling the radium down to the temperature of liquid hydrogen (20·3° absolute) during a period of 1½ hours does not cause a change in the γ-radiation of 1 in 1000, and probably not even of 1 in 5000. E. M.

97. *Experiments with the Active Deposit of Thorium.* **E. Marsden** and **R. H. Wilson.** (Phil. Mag. 26. pp. 354–361, Aug., 1913.)—In a scheme for the transformations in the active deposit of thorium suggested by Darwin and Marsden [Abstract No. 1714 (1912)], C_α and C_β were presumed to denote the same substance, ThC, breaking down in different ways, *i.e.* with the expulsion of an α- or a β-particle. Miss Meitner [Abstract No. 1715 (1912)], however, has obtained results which apparently show that the fraction of ThC, namely C_α, which gives rise to γ-ray product D, can be isolated and separated from the rest of the products. From the results of the present experiments it is concluded that Miss Meitner's experiments do not furnish sufficient evidence as to the existence of two separate products of about the same period in ThC, but that it is more probable that there are two methods of disintegration possible for the same atom. It is therefore suggested that the following scheme represents our present knowledge of the transformations in the active deposit of thorium.



A. E. G.

98. *Fluctuations of Concentration in Radio-active Solutions.* **T. Ehrenfest.** (Phys. Zeitschr. 14. pp. 675–676, Aug. 1, 1913.)—Re-examines the method of calculation adopted by Svedberg for the fluctuations of concentration to be expected in solutions of radio-active bodies [Abstract No. 730 (1913)]. Uses Bernoulli's exact formulæ instead of the approximate formulæ of Smoluchowski and Bateman. The calculated results of Svedberg and Wallgren do really follow from their premises, but it appears that these premises themselves imply a connection between fluctuations of concentration and of disintegration, and it is this implication which produces

the discrepancy between Svedberg on one hand and H. A. Lorentz, Smoluchowski, Langevin, and v. Schweidler on the other [Abstract No. 1218 (1913)]. E. E. F.

99. *Disintegration of Uranium X.* **A. Fleck.** (Phil. Mag. 26. pp. 528–535, Sept., 1913.)—The theoretical considerations regarding the evolution of the radio-elements through the periodic law put forward by various authors suggested that a then unknown β-ray product should exist between Ur and Io. Fajans and Göhring have announced the discovery of such a body, and in the present experiment this result is experimentally verified. A UrX solution is taken, and a lead plate immersed. It is found that the lead plate takes out of the solution a rapidly decaying product. Further investigation showed that this product can be partly isolated by precipitating bismuth oxychloride or lead chloride in a UrX solution, the new product being associated with the precipitate in each case. UrX therefore consists of two products, UrX_1 and UrX_2, the half-time periods being 24·6 days and 1·1 mins. respectively. The experiments further confirm Fajans and Göhring's result that the hard β-rays of UrX come from UrX_2 and the soft ones from UrX_1. The results also suggest that UrX_2 cannot be the parent of actinium. E. M.

100. *Branch Product in Actinium C.* **E. Marsden** and **R. H. Wilson.** (Nature, 92. p. 29, Sept. 11, 1913.)—It is now well established that the atoms of RaC and ThC can break up in two distinct ways, *i.e.* with the expulsion of either an α- or a β-particle. It is to be expected from the close analogy between the C products of the various radio-active families that AcC should also show abnormal disintegration, and, further, it might be anticipated that one of the branch products would emit an α-particle with great velocity and corresponding long range. The present experiments were made to test this point. A source of actinium active deposit was covered with a sheet of mica equivalent to about 5 cm. air, in stopping power of α-particles, and the whole placed in an exhausted chamber with a zinc sulphide screen about 2 cm. from the source. The numbers of scintillations appearing on the screen per min. for different pressures of the air inside the apparatus were counted, and thus the falling-off of the α-particles with "range" determined. The results showed that in addition to the α-particles of AcC with range 5·4 cm. a small number, about 1 in 600, can penetrate as far as about 6·45 cm. Special experiments showed that the long-range α-particles could not be due to radium or thorium impurity, and they must therefore be attributed to the expected new branch product. E. M.

101. *Distribution of the Active Deposit of Actinium in Electric Fields.* **H. P. Walmsley.** (Phil. Mag. 26. pp. 381–401, Sept., 1913.)—It is now generally accepted that the active deposits of Th and Ra carry positive charges, and are in consequence concentrated on the kathode in electric fields. Some doubt, however, has arisen in the case of Ac [Abstracts No. 2067 (1909), etc.]. The author first shows that in this type of experiment it is necessary to introduce "pure" emanation into the electric fields employed, *i.e.* emanation free from dust and active deposit. If any changes occur at all in the electrification of the active deposit, it is necessary to eliminate "old" deposit before employing electric fields. On this account it is undesirable to allow the emanation to diffuse directly from the actinium preparation into the field. These conditions apply particularly in the case of actinium emanation, as, owing to its quick disintegration (period 39 secs.), active deposit

atoms are soon associated with it. In the present experiments the emanation was blown into the ionisation chamber through a tube having its end filled with cotton-wool to remove the active deposit particles. In this way it was shown that all the atoms of both AcA and AcB acquire a positive charge in the moment of their creation. As regards their electrical properties, both AcA and AcB behave exactly like the positive ions produced by their radiations. They recombine in exactly the same way, and the activity collected by the anode in an electric field is due solely to deposit atoms which have recombined. Under favourable circumstances recombination continues until the whole of the active deposit is electrically neutral. E. M.

102. *Uranium Y.*—**G. N. Antonoff.** (Acad. Sci. St. Pétersbourg, Bull. 15. pp. 875–876, Nov. 1, 1913.)—In a previous paper [Abstract No. 1684 (1911)] the author described the separation of a product, UrY, which was presumed to be a small lateral disintegration product from Ur. Later Fleck questioned the existence of this product, and presumed that the anomalous results were due to thorium impurity. The present author has now repeated his experiments with purified uranium supplied by Soddy, and similar to that used by Fleck. The existence of UrY is reaffirmed, its activity being stated to be at least 2% of that of UrX. This activity is of the order of that required if UrY is the parent of the actinium family. E. M.

103. *Uranium X_2.*—**O. Hahn** and **L. Meitner.** (Phys. Zeitschr. 14. pp. 758–759, Aug. 15, 1913.)—The authors confirm the existence of UrX_2, discovered by Fagans and Göhring, and describe a simple method of isolating it. UrX, the parent of UrX_2, has the properties of thorium, whereas UrX_2 is allied to tantalum. The separation of the two products is therefore the same as that of the separation of Th and Ta. UrX solutions are heated with tantalum pentoxide and filtered. To reduce the adsorption of UrX by the Ta compounds, a small quantity of thorium nitrate is added. The half-period of UrX_2 is 1·17 mins. E. E. F.

104. *Complexity of Radio-Actinium.* **O. Hahn** and **L. Meitner.** (Phys. Zeitschr. 14. pp. 752–758, Aug. 15, 1913.)—Geiger's relation between the life-period of a radio-active substance and the range of its α-particles would indicate that radio-actinium consists of two bodies, one of half-period 19·5 days, giving β-rays, and one of half-period 1·5 days, giving α-rays. The authors study this question by means of the curves of increasing α- and β-radiation, and conclude that there is no evidence whatever for the second product. They put forward the following scheme to show the derivation of actinium—

$$\mathrm{UrI} \longrightarrow \mathrm{UrX_1} < \begin{array}{l} \mathrm{UrX_2—UrII—Io—Ra} \\ \mathrm{AcI—AcII—Radio\text{-}Ac—AcX} \end{array}$$

Of these, UrX_1, UrX_2, Radio-Ac, and possibly Ac2 emit β-rays, and Radio-Ac also emits α-rays. A difficulty lies in the formation of bivalent AcX from quadrivalent Radio-Ac, if α- and β-rays are emitted simultaneously, but similar difficulties are presented by Ra, ThX, and other products. E. E. F.

HEAT.

105. *Measurement of Specific Heats.* **F. A. Lindemann** and **F. Schwers.** (Phys. Zeitschr. 14. pp. 766–767, Aug. 15, 1913.)—Instead of calculating the heat supplied from the Joulean heating of a wire and the temperature from the temperature coefficient of resistance [Nernst and Eucken, Abstract No. 1714 (1909)], the authors propose to measure the temperature by inserting the substance direct into the bulb of a hydrogen thermometer. The method is described in detail, and applied to the specific heat of KCl. It is, however, of limited range of application, since powdered substances adsorb hydrogen in considerable quantity. It can be applied to metals and coarse-grained substances, and may be useful in measuring specific heats, say, at the temperature of liquid helium. E. E. F.

106. *Thermo-calorimetric Investigations on Platinum at High Temperatures.* **O. M. Corbino.** (N. Cimento, 5. Ser. 6, pp. 313–328, May, 1913.)—A modification of the method previously described [see Abstracts Nos. 1063, 1064 (1912)] is applied to the investigation of the specific heat of Pt. The specific heat at constant volume is found to have the following values in arbitrary units at the given temperatures (° C.) : 510°, 215 ; 740°, 219 ; 956°, 225 ; 1210°, 233 ; and 1525°, 244. The specific heat at constant volume hence rises almost linearly with the temperature. According to White's measurements [compare Koenigsberger, Abstract No. 878 (1912)], at 500° the value of the atomic heat is 6·47, on which basis its value at 1500° is 7·37. This result confirms the conclusion drawn from the measurements made with tungsten (*loc. cit.*), that with metals the atomic heat greatly exceeds the theoretical value. The author had hoped to make use of the relation between the specific heat and the variation of resistance with the temperature in order to measure high temperatures, but the inconstancy of the specific heat renders this impracticable. T. H. P.

107. *Evaporation Temperature of Carbon in the Arc Lamp.* **O. Lummer.** (Journ. f. Gasbeleuchtung, July 12, 1913. Abstract of paper read before the German Illuminating Engin. Soc. Electrical World, 62. p. 296, Aug. 9, 1913.) —If the carbon in the arc lamp has a temperature of evaporation the temperature of the carbon must be independent of the arc length and of the current, but must change with the atmospheric pressure as does the evaporation temperature of any substance. From tests made by the author it appears that the temperature is independent of the current. Further, the temperature of the positive crater decreases from 4000° abs. to 3800° if the pressure is reduced from 1 atmo. to 0·25 atmo. This indicates that the atmosphere of the crater is the boiling temperature of carbon. The tests are to be repeated and extended to 30 atmos. The negative crater has in general a lower temperature than the positive crater. The positive crater seems to begin to boil at temperatures below atmospheric. J. J. S.

108. *Vapour Pressures of Hydrogen from the Boiling-point down to near the Triple Point.* **H. Kamerlingh Onnes** and **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 440–445, Nov. 27, 1913. Com-

munication No. 187*d* from the Phys. Lab., Leiden.)—The value found for the heat of vaporisation of hydrogen at the boiling-point differs appreciably from those calculated by means of the Clausius-Clapeyron formula from the vapour pressures of hydrogen between the boiling-point and the triple point as determined by Dewar [Abstract No. 1757 (1905)] and by Travers, Senter, and Jaquerod [Abstract No. 1025 (1903)]. The authors have therefore made fresh measurements of the vapour pressure of hydrogen in this region, making use of an apparatus similar to that described by Onnes and Braak (Ibid. May, 1908). The results obtained show that the curve representing log p as a function of 1/T is slightly concave upwards, whereas Travers and Jaquerod's numbers give a curve slightly convex upwards. The Wrede-Rankine-Keesom formula, $\log p = 4{\cdot}6063 - 58{\cdot}40/T + 61/T^2$, gives values of p differing but little from the observed numbers, and gives for the boiling-point the value 20·33° K. or — 252·76° C. The heat of vaporisation of hydrogen at 75·15 cm. is calculated to be 105·5 cals., which is smaller than that found by direct measurement at the lowest velocity of evaporation, namely, 110·2. This result perhaps indicates insufficient care to prevent condensation of the vaporised hydrogen in the calorimeter. Indeed, when the velocity of vaporisation was doubled, smaller values were obtained: 108·5 and 109·3 at pressures of 76·1 and 77·75 cm. respectively. T. H. P.

109. *Equilibrium-diagram of Water*. **G. Tammann.** (Gesell. Wiss. Göttingen, Nachr., Math.-phys. Klasse, 1. pp. 99–136, 1913.)—The author calls attention to the fact that if light ice is converted partially by pressure into dense ice, the pressure-temperature curve of equilibrium differs according as the dense ice was prepared above — 30° or between — 70° and — 80°. These curves are most conveniently followed by recording the equilibrium pressures as the temperature is varied. The remarkable fact is that these two curves intersect one another, but without giving the usual properties of a triple point. The existence of an equilibrium-curve (nearly parallel to the axis of pressure) between dense Ice II and dense Ice III is confirmed, but this does not account completely for the phenomena in question. The existence of a new variety of Ice III, more stable than the former one (now called Ice III′), is recorded; it is prepared from water at — 35° and 2900 kg./cm.^{2}, whereas the other form is prepared from Ice II by warming up from — 70°; being the more stable form it melts at a higher temperature, — 15·9° (corr. — 17·4) instead of — 18·4° (corr. — 19·9) at 2513 kg./cm.^{2} pressure. Ice III′ can be prepared by compressing water to 2800 kg./cm.^{2} and cooling *slowly*. If the volume is increased at a temperature above — 30° a partial conversion to light ice takes place, but the equilibrium curve differs from that for Ice I and Ice III′, and is attributed to the formation of a new light Ice I′. The melting-point curve for Ice I′ lies below that of ordinary Ice I — about 0·5° lower at 500 kg./cm.^{2} and diminishing to 0·15° lower at 2100 kg./cm.^{2}. The existence of two other uncommon forms of light ice is indicated: these are referred to provisionally as Ice I″ and Ice I‴. Ice I′ is possibly identical with the Ice IV of a previous paper, but the hint is given that there may be not less than seven forms of light ice, in addition to some five forms of dense ice. The author proposes to classify them in groups; the members of each group are found to cover much the same area in the p.T diagram and are thought to contain identical molecules, whereas the groups themselves, I, II, III, V, VI, may represent different molecular structures. T. M. L.

110. *Radiation*. **J. E. Ives.** (Journ. Acad. Nat. Sciences, Philadelphia, 25. pp. 349–362, March, 1912.)—A discussion of the ether and radiation,

involving the relativity principle and the quantum hypothesis, the chief conclusions of which may be stated as follows :—(1) Energy has no real existence independently of matter, and cannot exist free in space. (2) The types of electrical oscillators are very numerous, and it is improbable that the Hertz oscillator can be considered the sole elementary type. (3) The so-called velocity of light is not a quantity of the nature of a mechanical velocity. Its reciprocal may, perhaps, be regarded as of the nature of a time reaction constant. (4) Planck's energy-quantum hypothesis is a statistical hypothesis, and probably only true for the short waves of heat and light, and not for long electric waves. (5) Einstein's hypothesis of the light-quantum is untenable because it is based on the assumption that energy can exist free in space. E. H. B.

111. *Black-body and True Temperatures for Tungsten, Tantalum, Molybdenum, and Carbon.* **C. E. Mendenhall** and **W. E. Forsythe.** (Astrophys. Journ. 37. pp. 380–390, June, 1913.)—The increasing use of various electrically-heated metallic filaments in a variety of physical experiments, together with the difficulty of determining the true temperature of such filaments, suggested the desirability of securing data for finding the true temperature of the radiating surface from the more readily observed optical black-body temperature. Details of the method have already been published [see Abstract No. 770 (1911)]. The results are given in graphical form, indicating in most cases a slight curvature of the TS-curve, especially for the lower range of temperatures. In the case of molybdenum the relation is linear from 1500° up, and for tungsten from 1000° to 3000°. It is concluded that the optical absorbing power of these four substances varies with temperature instead of being constant as hitherto considered. C. P. B.

112. *Melting-point of Molybdenum.* **C. E. Mendenhall** and **W. E. Forsythe.** (Astrophys. Journ. 38. pp. 196–198, Sept., 1913.)—A direct determination of the melting-point of molybdenum by the V-method [see preceding Abstract], gives the value of the true melting-point as 2535° C., and the black-body melting-point, 2237° C. for $\lambda = 0{\cdot}658\ \mu$. These temperatures are on basis of $C_2 = 14{,}500$, and palladium melting-point 1549° C. Comparisons are given with results of other workers. C. P. B.

113. *Deduction of Planck's Law of the Distribution of Energy from the Agglomeration Hypothesis.* **C. Benedicks.** (Ann. d. Physik, 42. 1. pp. 133–162, Aug. 26, 1913.)—The full paper corresponding to Abstract No. 1453 (1913).

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

114. *Free Electrons in Non-magnetic Metals.* **T. Otashiro.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 118–123, July, 1913.)—From the experimental results as to the Hall-effect and the electric current, it is here calculated that the number of free corpuscles per cm.^{3} of non-magnetic metals lies between 10^{22} and 10^{23}. E. H. B.

115. *Electromagnetic Induction.* **S. J. Barnett.** (Phys. Rev. 2. Ser. 2. pp. 323–326, Oct., 1913.)—The author here defends and maintains his criticism of the work on unipolar induction by E. H. Kennard. [See Abstracts Nos. 210 and 1179 (1913).] It is here pointed out that there is no justification for the assumption made by Kennard that $div\, E = 0$. In conclusion, the author considers briefly what happens on the theories of Hertz, Einstein, and Lorentz, in each of the two principal experiments involved in the discussion of relative motion. The case in which the condenser rotates will be called Case I., that in which the condenser remains at rest as Case II.

On the theory of Hertz, the condenser is uncharged in Case I. and also in Case II. On Einstein's theory the condenser is charged (as indicated in the present paper) in Case I., and also in Case II. On the theory of Lorentz the condenser is charged (as in this paper) in Case I., and is uncharged in Case II. Lorentz's theory is thus the only one which is consistent with both sets of experiments. E. H. B.

116. *Elementary Electric Charge and Avogadro's Constant.* **R. A. Millikan.** (Phys. Rev. 2. Ser. 2. pp. 109–143, Aug., 1913. Phys. Zeitschr. 14. pp. 796–812, Sept. 1, 1913.)—The errors involved in the determination of the electronic charge by the oil-drop method [Abstract No. 943 (1911)] affect the density of oil and air, the electrostatic field, the viscosity of air the velocities of fall under gravitation and rise in the electrostatic field, the radius of the drop, and the correction necessitated by the failure of Stokes' law when the diam. of the drop is of the same order of magnitude as the mean free path of a gaseous molecule. After discussing these sources of error at considerable length, the author arrives at the following final values :—

Electronic charge $e = 4{\cdot}774 \pm 0{\cdot}009 \times 10^{-10}$.
Molecules in a gr.-molecule $N = 6{\cdot}062 \pm 0{\cdot}012 \times 10^{23}$.
Gaseous molecules in 1 cm.^{3} at N.T.P. $n = 2{\cdot}705 \pm 0{\cdot}005 \times 10^{19}$.
Molecular kinetic energy at 0° C. $E = 5{\cdot}621 \pm 0{\cdot}010 \times 10^{-14}$.
Constant of molecular energy $\epsilon = 2{\cdot}058 \pm 0{\cdot}004 \times 10^{-16}$.
Constant of entropy equation $k = 1{\cdot}372 \pm 0{\cdot}002 \times 10^{-16}$.
Action constant $h = 6{\cdot}621 \pm 0{\cdot}025 \times 10^{-27}$.
Constant of Wien's displacement law $C_2 = 1{\cdot}4470 \pm 0{\cdot}0030$.

E. E. F.

117. *International Agreement on Potential and Elasticity.* **A. Korn.** (Elektrotechnik u. Maschinenbau, 31. pp. 861–864, Oct. 12, 1913. Paper read

before the 85. Naturforscherversamml., Vienna. Phys. Zeitschr. 15. pp. 1105–1109, Nov. 15, 1913.)—Describes in general terms the objects and methods of the proposed international conference on the possible agreement or standardisation of the more important conceptions and symbols in connection with the theories of potential and elasticity. E. H. B.

118. *Quaternion and Binary Forms of Minkowski's Electrodynamic Equations.* I. **E. Waelsch.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 503–513, March, 1913.)—Mathematical. E. H. B.

119. *Vector Potential in Relation to Vector Angle.* **F. Slate.** (Phys. Rev. 2. Ser. 2. pp. 211–216, Sept., 1913.)—The author discusses the Vector Potential and gives various physical meanings to it, with the object of clearing up the mathematical haze in which it is enveloped. A. R.

120. *Rotatory Field Phenomena in Electrostatic Alternating Field.* **E[mma] Becker.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 515–584, March, 1913.)—It had been supposed that the sense of the rotation of the field depended on the diam. of the body introduced in the alternating field, but it is here shown theoretically and experimentally that the thickness of the body has no influence on the sense of rotation. [See Abstracts Nos. 101 (1908) and 536 (1912).] E. H. B.

121. *Adsorption of Ions by Falling Drops, etc.* **R. Lehnhardt.** (Ann. d. Physik, 42. 1. pp. 45–66, Aug. 26, 1913. Extract from Dissertation, Berlin.)—A. Schmauss found [Abstract No. 460 (1903)] that water-drops falling through gases ionised by Röntgen rays adsorbed negative ions much more freely than positive. This was explained as being due to the higher mobility of the negative ions. R. Seeliger [Abstract No. 710 (1910)] working with continuous Röntgen radiation obtained a far smaller excess of negative ions adsorbed. Repeating Seeliger's experiments, but protecting the falling drops from Röntgen rays, the author obtains an intermediate ratio for uncharged droplets. The power of adsorption seemed to increase with the dielectric constant. With droplets equally and oppositely charged the number of adsorbed ions corresponds to the ratio of the mobilities of the ions attracted. Direct tests of the adsorbability of ions by falling steel balls showed ultimately that the adsorption is directly proportional to the mobility. Causes of divergence from this result are discussed. A. D.

122. *Calculation of the Capacity Coefficients for Two Unequal Spherical Electrodes.* **A. Guillet** and **M. Aubert.** (Journ. de Physique, 3. Ser. 5. pp. 713–724, Sept., 1913.)—The authors consider the case of two unequal spherical conductors external to one another. Using the method of images they get the series formulæ in terms of spherical functions analogous to those of Heine. No numerical examples are given. A. R.

DISCHARGE AND OSCILLATIONS.

123. *Field-canal Rays.* **E. Wagner** and **J. Kutschewski.** (Ann. d. Physik, 42. 3. pp. 665–672, Oct. 16, 1913.)—The name "Feldkanalstrahlen" is now applied to those canal rays moving towards the anode which are generated in an applied field. In the experiments they are differentiated from the

K_1 or retrograde rays and are also compared, as regards the Doppler-effect, with the primary canal rays under conditions of generation which are so far as possible similar. [See also Abstract No. 1474 (1913).] A. E. G.

124. *Helix of Wehnelt Kathode Rays used to Determine e/m and v.* **J. B. Nathanson.** (Phys. Rev. 2. Ser. 2. pp. 307–313, Oct., 1913.)—The helical path in the case of these rays was realised as follows. The rays were projected from a Wehnelt kathode in a direction perpendicular to the lines of force of a uniform magnetic field. The path assumed by the rays was a circle. Upon application of a uniform electrostatic field coinciding with the magnetic one, the circle was drawn out into the form of a helix. The values found are given in the table :—

Gauss. H.	Volts: V.	$(e/m) \times 10^{-7}$.	$v \times 10^{-9}$.
18·84	81·3	1·71	1·62
22·78	81·2	1·39	1·21
19·01	79·5	0·56	1·14
26·84	119·5	0·27	1·09
18·27	80·0	0·64	1·49
21·41	119·3	0·46	1·20
19·58	79·5	0·59	1·44
16·56	120·0	0·70	1·43
20·67	83·0	1·44	1·20
16·56	120·0	1·91	1·63
20·61	126·0	1·71	1·53
19·13	43·0	2·07	1·75
23·98	120·0	1·49	1·29
	Mean.........	1·61	1·39

[See Abstract No. 556 (1912).] E. H. B.

125. *The Cause of Emission of Electrons from Hot Kathodes.* **A. Gehrts.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1047–1056, Oct. 30, 1913. Communication from the Physikal. Versuchsabteilung d. Accumulatoren-Fabrik A.G.) —While agreeing with the main points of the theory put forward by Fredenhagen the view is now expressed that the decomposition of the oxide is not occasioned by the current flowing from the anode to the kathode, but is produced essentially by thermic dissociation. In the experiments described on the chemical alteration of the oxide kathode by the passage of the current it is found that neutral calcium and oxygen atoms must be present in the oxide layer. Further experiments on the behaviour of oxide kathodes in different gases are being carried out. A. E. G.

126. *Monomolecular Ions in Gases, and New Method of Measuring Dimensions of Molecules.* **W. Altberg.** (Russian Physico-Chemical Soc., Journ. 44. No. 8. pp. 431–458, 1912.)—Gives first a review of P. Lenard's explanation of the formation of ions [Abstracts Nos. 650 (1903) and 2958 (1904)]. A. Becker [Abstract No. 1939 (1909)] has fully explained the case of small ions, and also has shown that the motion of ions depends on their growth [Abstract No. 66 (1912)]); but the case of more rapid ions has not till now been determined by means of cylindrical condenser. The author made a few tests with the same gas but employing different gas velocities; the distance of the nets also changed. For the observations negative ions in CO_2 were used.

Density of Ions.—To ascertain if the position of point of intersection has any influence upon the density of ions the intensity of the Röntgen rays was weakened by means of an Al plate 0·5 mm. thick and both curves were kept under observation, first for the weakened rays and afterwards for the unweakened rays. The points of intersection, it was found, did not change, though the density of the ions was changed in proportion of 1 : 8.

Growth of Ions.—Change in distance of the measuring net from the X-rays, necessitates change in the time taken for the ions to reach the net; this brings about ions of different sizes, and to test this growth a large condenser with nettings placed at a distance of 7 cm. was used.

From observation of mobilities it is found, as shown in the table below, that the dimensions of ions are nearly equal to the calculated radius of the molecule. It is hence inferred that the most rapid ions observed with the help of the net condenser can be considered as being separate molecules.

Gas.		Air.	CO_2.	O_2.	N_2.	H_2.
Ohms defined in cm./sec.$^{-1}$/volt cm.$^{-2}$	Positive	7·5	5·7	7·6	7·0	(105)
	Negative	10·1	5·8	10·3	(9·5)^5)	(152)
Dimensions of ions, $\nu \times 10^9$ cm.	Positive	21·5	19·2	20·8	22·9	(7·9)
	Negative	16·6	18·9	15·8	(17·6)	(4·7)

The question of mixed gases is also investigated. I. P.

127. *Photoelectric Properties and Contact Resistance of Thin Kathode Films.* **O. Stuhlmann, Jr., and K. T. Compton.** (Phys. Rev. 2. Ser. 2. pp. 199–210, Sept., 1913.)—The relation between the velocity of the electrons emitted by the action of light on metals and the frequency of the light has been deduced by Einstein on the unitary theory of light, and Richardson derived the same equation by thermodynamic and statistical methods which do not necessarily involve the unitary light hypothesis [Abstract No. 1414 (1912)]. Several investigators have succeeded in obtaining electric velocities considerably higher than those ordinarily obtained in photoelectric measurements. Most of these high velocities have been obtained when sparks were used as the source of light. These have been shown to be due to secondary action from electromagnetic radiation accompanying the spark discharge. O. v. Baeyer and Gehrts, and more recently Dike and Brown have obtained high velocities in other ways. It becomes necessary to discover some error in the results or interpretation of the results given by Dike or to reject Richardson's theory. It seems probable that the great increase in the photoelectric potentials following an induction coil discharge may be due principally or entirely to a great increase in the contact p.d. Thus the initial kinetic energy with which the electrons leave the metal film may have the ordinary value predicted by Richardson's theory. After emission this velocity may be greatly increased by the expulsion due to an absorbed negative charge in the sputtered plate or due to their passage through a charged insulating layer, deposited on the

surface by the induction coil discharge. The present experiments are undertaken to test these explanations of apparent high velocities. As a result it is concluded that the high potentials observed by Dike and Brown must be ascribed to the presence of oil or grease, introduced while making the metal apparatus, to vacuum wax in the ground joints, or to some other material which could produce a charged layer. There is no evidence in these experiments to show that the photoelectric velocities should be different from those predicted by Richardson's theory. Saturation currents and contact resistances are also investigated. It is evidently a very difficult matter to make good electrical contact with very thin films. Patterson, when experimenting with the specific resistance of thin metal films found that for very thin Pt-films the specific resistance increased more rapidly than was predicted by the electron theory of conduction suggested by J. J. Thomson. It seems probable that all or part of this unpredicted increase may be due to high contact resistance superposed on the regular resistance of the film. If this is true it would explain the discrepancy between theory and experiment in the case of very thin films. A. E. G.

128. *Relation between Photoelectric Currents and Light Intensity.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 14. pp. 741–752, Sept. 1, 1913.)—Discusses the various factors which may interfere with the proportionality of photoelectric discharge from a potassium or rubidium cell and the light intensity. The dark discharge and the dark after-effect are attributable to charges on the glass wall of the cell, and means of avoiding these are indicated. The photo current is then found for a wide range of illuminations, varying from 1/3 of bright sunlight (about 30,000 lux) down to about 6×10^{-4} lux. On taking each of the sources in steps regulated by Nicol prisms, proportionality was found to hold good along the entire range. The lowest illumination reached was 2·4 microlux, which, with a voltage of 200, gave a current of $1{\cdot}79 \times 10^{-12}$ amp., as measured by an electrometer method. E. E. F.

129. *Photoelectric Properties of Liquids.* **M. La Rosa** and **V. Cavallaro.** (N. Cimento, 6. Ser. 6. pp. 39–47, July, 1913.)—Observing photoelectric discharges from liquids illuminated by a carbon arc or quartz mercury lamp by means of a quadrant electrometer, the authors found both the Hallwachs and the Lenard effects, usually superposed. Thus it may happen that some bodies dissipate a negative charge more readily, others a positive charge, while others again dissipate neither. The Hallwachs phenomenon is dominant in water, ethyl alcohol, and acetic ether, while the Lenard-effect (neutralisation of positive charge by external negative ions) is dominant in ethyl ether and in methylene bromide. E. E. F.

130. *Influence of Discharge on the Photoelectric Effect.* **H. Greinacher.** (Deutsch. Phys. Gesell., Verh. 15. 17. pp. 797–808, Sept. 15, 1913.)—The paper is a preliminary account of experiments made to test the action of the discharge in hydrogen, air, and oxygen upon the photoelectric effect of Pt, Pb, Zn, Al, Cu, and Au, these metals being used as the kathode. As observed by Elster and Geitel with Na and K alloy [see Abstract No. 1381 (1911)] the discharge in hydrogen increases the effect enormously. Air and oxygen, however, give a marked decrease. In some cases by using air and hydrogen alternately, it is possible to vary the effect repeatedly in the ratio 1 to 1000. With Zn and Al the activity imparted by the hydrogen discharge is much more permanent than with the other metals, the discharge in air having to be

repeated several times in order to get an appreciable reduction. In the light of these experiments the peculiar results obtained on the fatigue and increase of the photoelectric effect are not surprising. The author inclines to the view that the effects observed by him are chemical in origin. F. J. H.

131. *Ionomagnetic Rotations.* **A. Righi.** (Phys. Zeitschr. 14. 688–703, Aug. 1, 1913. N. Cimento, 6. Ser. 6. pp. 5–38, July, 1913.)—Describes a large number of experiments to illustrate ionomagnetic rotations [Abstract No. 1877 (1912)] and works out their theory. One of the electrodes in a vacuum tube is surrounded by a very light cylinder, usually made of Al-foil 0·02 mm. thick. The other electrode is, in one form of the apparatus, coaxial with the first. The axis of the electromagnetic is vertical and coincides with that of the electrodes. The light Al cylinder is suspended vertically by a quartz or cocoon fibre. The rotations produced come to an end when the torsional moment of the fibre equals the moment of the ionic impacts. If the central electrode is a kathode, the cylinder acts as a secondary kathode, and any electron expelled from it is deflected in a more or less tangential direction. Any α-particle, due to its ionising power, which would ordinarily fall vertically upon the surface, is rotated in the same tangential direction. So the discharge proceeds round the cylinder. The author has devised a number of experiments which eliminate alternative explanations. E. E. F.

132. *Ions from Hot Salts.* **O. W. Richardson.** (Phil. Mag. 26. pp. 452–472, Sept., 1913.)—The chief object of the investigation is the measurement of the specific charge or the molecular weight of the emitted ions. The salts tested are: ZnI_2, CdI_2, CaI_2, $CaBr_2$, CaF_2, SrI_2, BaI_2, Fe_2Cl_6, and $MnCl_2$. The necessary modifications of previous apparatus are briefly described. The method now adopted has the great advantage that a determination of e/m only requires a minute or two, so that the variations of this quantity can be followed even when it is changing rather rapidly. On the other hand it only gives a kind of average value if more than one kind of ion is present. The results obtained are in good agreement with those got by the previous method. In all cases the salts are heated on a flat strip of Pt which has been glowed out previously until it has lost its power of emitting ions at the temperature of the experiments. For the positive ions the following results are obtained: With ZnI_2, unless the rather copious ionisation, when the salt is freshly heated, all arises from contamination by impurities, which seems unlikely, practically all the ions are Zn_{++} and not Zn_{+}. With CdI_2 the ions given off have an electric atomic weight corresponding to Cd_{++}. The high temperatures at which this effect is observed are against the view that the ions are produced directly by the action of heat on the iodide itself; since, at these low pressures, it would presumably have evaporated before the temperatures recorded were attained. These ions probably arise either from the action on the hot Pt of CdI_2 vapour which comes from cooler parts of the strip, or else from some less volatile substance with which the iodide is contaminated. It is possible that somewhat similar considerations apply to the ions emitted by ZnI_2. With SrI_2 the values of m/H are in satisfactory agreement with the chemical equivalent of $Sr_{+} = 87{\cdot}6$ and confirm the results obtained by Davisson with other strontium salts. With Fe_2Cl_6 there seems to be satisfactory reason for supposing that the numbers obtained indicate the presence of potassium as an impurity. With $MnCl_2$ the electric molecular weight increased from 33·8 to 79·4 and then fell back to 39·2. The light ions might be Mn_{++} but on the whole Na_{+} and K_{+} are more probable. The

heavy ions point to the existence of $MnCl_2$ and possibly also Mn_+. For the negative ions the following results are obtained. With CaI_2 there is a very large emission of negative ions at comparatively low temperatures. This property is also shown by the iodides of the other metals of the alkaline earths. In general the negative ions emitted by these substances are not all electrons, but consist of a mixture of electrons and heavy ions. Thus when a fresh specimen of CaI_2 is heated at a low temperature practically all the negative emission is carried by heavy ions and it is shown that these heavy ions are atoms of iodine combined with a single electron. At higher temperatures a much larger proportion of the current is carried by electrons. The iodides of Sr and Ba behave in a similar manner with respect to the emission of negative ions to that of Ca as do also CdI_2 although in this case the conditions are rather complicated. The other salts examined are Fe_2Cl_6, $MnCl_2$, CaF_2, and $CaBr_2$. It is curious that the deviations of the observed values of m/H from the calculated values for the ions to which they are attributed are in every case, for the heavy ions examined, in such a direction as would occur if the ions in question were mixed with another kind for which $m/H =$ about 100. A. E. G.

133. *Absorption of Heat produced by the Emission of Ions from Hot Bodies.* **H. L. Cooke** and **O. W. Richardson.** (Phil. Mag. 26. pp. 472–476, Sept., 1913.)—The authors have recently shown [Abstract No. 1186 (1913)] that when a current of negative electrons is allowed to flow from a heated filament of osmium, there is an absorption of heat which is equal in amount to the energy required to drive the escaping electrons through a p.d. of 4·7 volts. The present paper deals with similar experiments made with lime-coated Pt wires and with tungsten wires. The behaviour of the former is found to be quite different from that of the osmium and tungsten wires. The turning-on of the thermionic current causes a decrease in the resistance of the wire under examination. The nature of the charge is not, however, similar to that observed with osmium and tungsten wires, but rather indicates a fairly steady rate of decrease in the resistance with the time. It seems evident that this change in resistance is not to be ascribed to a cooling effect. The data obtained would be satisfactorily explained on the assumption that this effect is due to an increase in the radiating power of the surface of the lime brought about by electrolytic effects in the lime occasioned by the passage through it of the thermionic current. With tungsten wires the change of resistance due to turning the thermionic current on or off is complete in a few seconds, and the cooling effect when the current is turned on is equal to the heating effect when the current is turned off. An erroneous statement was made in the former paper (*loc. cit.*) to the effect that a small systematic error makes the measured value of ϕ too small. It is now found that this value is too large; consequently, the suggested increase of ϕ with θ cannot be regarded as established by experiment. They are, in fact, insufficiently accurate for the purpose. A. E. G.

134. *Temperature and Surface Conditions which affect the Positive Ionisation from Heated Platinum.* **C. Sheard** and **D. A. Woodbury.** (Phys. Rev. 2. Ser. 2. pp. 288–298, Oct., 1913.)—An experimental research leading to the following conclusions:—Two sources capable of producing thermions are present as impurities in Pt. One source of ionisation is more easily driven out by heating than the other. After continued heating, and when investigated within the proper temperature region, two distinct types of current-

time curves are obtained: one showing a decay with time from an initial maximum, the other giving rise, after two or three minutes' heating, to a maximum, followed by the usual decay effects. The thermionic emission from a wire which has lost its power of producing ions may be enhanced and made comparable with the initial effects by (*a*) heating in a Bunsen flame, (*b*) heating electrically in hydrogen, (*c*) cleaning the wire with acid. [See Abstracts Nos. 118 and 258 (1911)], also No. 1028 (1913).] E. H. B.

135. *The Energy of Electron Emission of Glowing Bodies.* **A. Wehnelt** and **E. Liebreich.** (Deutsch. Phys. Gesell., Verh. 15. 20. pp. 1057–1062, Oct. 30, 1913.)—It is shown that with CaO the value of the emission depends upon the time, after the beginning of the glowing, at which the measurements are made. The large value for Φ which has recently been found by Richardson has not been observed in the present experiments. It is, however, stated that the max. value of 100 volts as given by him lies in the region of probability. A further condition which must be taken into consideration in this kind of measurement is that the obtained values of Φ are dependent on the vacuum. With pure Pt the values found for Φ lie between 5.78 and 6·04. From these experiments it follows that the value of Φ required by Richardson's theory for pure metals is in close agreement with the experimental results, but that CaO does not behave in accord with the theory. Further experiments are in progress. A. E. G.

136. *Ring Discharge without Electrodes.* **R. Wachsmuth** and **B. Winawer.** (Ann. d. Physik, 42. 3. pp. 585–613, Oct. 16, 1913.)—For a given excitation, continuous rarefaction reaches a pressure p_1, at which the energy of the shock is sufficient to ionise the gas; and p_1 depends on the nature of the gas. On still further rarefaction the gas behaves as if it were exposed to a constant ionisator; the number of the ions produced and their velocity vary in a similar manner with the pressure, and the conductivity curves are entirely analogous. In this case the luminosity is feeble, and the strongest lines of the ultimate spectrum are mostly absent. On still greater rarefaction a second characteristic pressure, p_2, is reached. At this pressure there is strong ionisation, a more intense light, and the ultimate spectrum appears in full. The numerical estimation of the energy of the shock in this case is difficult, but it is, say, from 25 to 30 times that at pressure p_1. It varies from gas to gas, in the same order as that under pressure p_1; the order being He, Ne, Ar, H_2, O_2, N_2, with Hg very nearly in the same place as O_2. Hg gives a continuous spectrum at feeble ionisations, a line spectrum at powerful. At the second pressure, p_2, a more powerful absorption of energy sets in. Photographs of spectra obtained accompany the paper. A. D.

137. *Effect of Pressure on Electric Wind from a Discharging Point.* **J. R. Boon.** (Phil. Mag. 26. pp. 694–701, Oct., 1913.)—An improved apparatus for the measurement of the pressure of the electric wind from point-plate discharge under different atmospheric pressures is set up and described. The curves of wind-pressure p and distance z between the electrodes agree in form at normal atmospheric pressure with those of other observers, and cut the z axis at a distance z_0 from the origin. The results at different atmospheric pressures π, in air and CO_2, show that z_0 is inversely proportional to π. This supports the view that z_0 is the result of intense ionisation possibly brought about by radiations from the point, which are absorbed in a given gas according to a density law. E. H. B.

138. *Point Discharge in Magnetic and Electrostatic Fields.* **O. W. Silvey.** (Phys. Zeitschr. 14. pp. 816–823, Sept. 1, 1913.)—The discharge between fine brass points at ordinary pressure is photographed by a shadow-method in an arrangement resembling a pinhole camera of great length. By finding electric and magnetic fields which produce the same effect on the discharge, the author attempts to arrive at the velocity of the positive ions. The value obtained is $4{\cdot}7 \times 10^7$ cm./sec. E. E. F.

139. *Influence of Ultra-violet Light on the Discharge from Points.* **W. Gerlach** and **E. Meyer.** (Deutsch. Phys. Gesell. Verh. 15. 20. pp. 1037–1046, Oct. 30, 1913.)—Pringsheim has found [Abstract No. 1988 (1913)] that the discharge does not take place instantaneously when the ultra-violet light is allowed to act. The object of the present paper is to show that this so-called "lag" in connection with discharges from points is only of secondary importance. The experiments show that with negatively as well as positively charged "sensitive" points in air, when acted upon by ultra-violet light, the lag of the discharge diminishes with decreasing pressure. From this it is concluded that this lag with regard to the photoelectric effect can only be considered of secondary importance. With the lower pressures employed the lag diminishes with increasing intensity of light. A. E. G.

140. *Pressure Gradient produced in Gaseous Discharge by a Transverse Magnetic Field.* **H. Sirk.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 417–475, Feb., 1913.)—On the assumption that the discharge in a gas is a convective transport of charged particles and that the mean free path of these is small compared with the dimensions of the discharge tube, the pressure-difference which should be produced across the discharge upon the establishment of a transverse magnetic field is calculated. If H is the value of this field, j the current density, and l the width of the discharge measured at right angles to the magnetic field, the pressure-difference in this same direction produced by the magnetic field is given by the equation $\Delta p = Hjl$. Experiments are described by which this formula is tested. A torsion manometer of special construction, which together with its calibration is fully described in the paper, is used to measure the very small pressure-difference produced, being attached to tubes sealed to the discharge tube at opposite ends of a diameter. Tables of results with various forms of discharge tube are given, which show that the effect is proportional to the magnetic field and to the current, and also that it is reversed with a reversal of either of these. The form of discharge tube found to be most suitable for obtaining results with which to test the theory is one having large Al electrodes at the ends of a constriction into which the pressure sounds are sealed. A good agreement is obtained between the observed and calculated values of the pressure-difference across the tube. F. J. H.

141. *Heating Effects at the Kathode in Vacuum Tubes.* **B. Hodgson** and **P. A. Mainstone.** (Phil. Mag. 26. pp. 411–422, Sept., 1913.)—The paper is a continuation of the work of one of the authors [see Abstract No. 1187 (1913)]. The quantity of heat energy communicated to the kathode is determined by its rise of temperature, measured by a mercury thermometer, and is found to be proportional to the current while the kathode glow is normal, but with the abnormal glow the heat given increases more rapidly as the current increases. Determinations of the rates of cooling of the kathode at various temperatures and of its thermal capacity enable the authors to obtain the

quantity of energy communicated per sec. On the assumption that the whole of the current at the kathode is carried by positive ions, the product of the current and kathode-fall should also give this amount of energy. The amounts of energy obtained by these two methods are found to be the same with oxygen and hydrogen. Measurements with air, and nitrogen containing traces of oxygen revealed the fact that in both cases the positive ions bombarding the kathode had fallen through the kathode fall of potential for oxygen. Irregularities in the readings were found to be due to the gases coming off from the electrodes. F. J. H.

142. *Rotations in the Iron Arc.* **W. G. Cady.** (Phys. Rev. 2. Ser. 2. pp. 249–269, Oct., 1913.)—The author has described in previous papers the rotation found at the anode of the iron arc in air [see Abstract No. 115 (1908)]. Subsequent experiments have shown that the phenomenon is more complicated than was at first supposed. Stated briefly, the phenomena are as follows. When the anode is sufficiently oxidised, so that a smooth molten globule of oxide is formed, the positive base of the arc has a tendency to rotate, the appearance produced being that of a minute ring of light at the anode. As the current is increased from about 1·5 to 2·5 amps., four characteristic types of rotation are successively observed. The transition from one type to the next is marked by a distinct and sudden change in the diam. of the ring and the speed of rotation of the arc. This is the normal sequence of events in the iron arc as the current increases. Up to about 1·5 amps. the anode globule, though brightly incandescent, is not being converted into vapour. In this stage there is only a glow discharge at the anode. At about 1·5 amps. the current jumps abruptly one or two tenths of an amp., and the second stage begins. In this case the positive base of the discharge is concentrated on a spot similar to that at the kathode, and a hissing sound is heard due to the vaporisation. A close examination of the magnified image shows that the positive base is in the form of a ring having a dark centre. In certain cases a faint wavering high-pitched note can be heard. This is the first of the four types of rotation (type A). The second (type B) begins when the current lies in value between 1·67 and 1·73 amps. The ring has a smaller diam., and the rapidity of the rotations is greater than in type A. At 1·80 amps. type B suddenly changes to type C. In this case the diam. of the ring is much larger, and the rapidity of the rotations is much smaller. This type is by far the most conspicuous, and is the one the author described in his early papers. This arc makes an audible note. At 1·88 amps. the fourth type of rotation D begins. In air this type lasts up to about 5 amps. With increasing current the frequency falls and the diam. increases; above 3 amps., however, the motion is very irregular. The author considers that the rotations are probably due to modifications in the composition of the globule of oxide at the anode. A. R.

143. *Damping of Oscillatory Discharges.* **F. L. Talamo.** (N. Cimento, 6. Ser. 6. pp. 48–58, July, 1913.)—Determines the damping of electric oscillatory spark discharges in air by a modification of Rutherford's method. The damping increases with the pressure, rapidly at first, and then more slowly (between 96 and 136 cm. of mercury), and finally again rapidly. The damping decreases with increase of sparking distance to a minimum at 4 or 5 mm. This contradicts Brooks, but agrees with Beaulard, Zenneck, and Drude. On reducing the pressure, the damping decreases at an approximately uniform rate. The influence of the spark-length is in the same direction at all pressures. E. E. F.

144. *The Goldschmidt Dynamo and Electromagnetic Wave Transmission.* **O. Lodge.** (Phil. Mag. 25. pp. 757–791, June, 1913. Electrician, 71. pp. 767–770, Aug. 15, 1913. Abstract. Jahrbuch d. drahtlosen Telegraphie, 7. pp. 514–521, Nov., 1913.)—Gives a theory of the Goldschmidt generator for high-frequency currents, together with a discussion concerning the propagation of ether waves through the atmosphere, with especial reference to the curvature of the earth. In the first part there is a description of the general principle of the Goldschmidt generator, with the differential equations for the action and reaction currents in the rotor and stator. These equations are—

$$x = M/R \,.\, d/dt \,.\, (y \cos pt)$$

and

$$y = y_0 + M/R' \,.\, d/dt \,.\, (x \cos pt),$$

where x is the rotor current, y the stator current, and M the mutual induction when the poles are opposite each other. These equations are worked out in steps, and it is shown that the rotor currents are arranged according to sine functions of the odd multiples of the fundamental frequency, whereas the stator currents are arranged according to cosine functions of the even multiples of the same frequency. This solution is carried out for all frequencies up to the factor 10, and the general law of coefficients is indicated. Special attention is devoted to the practically important case in which the highest factor is 4. In an appendix the above equations are treated more rigidly and general solutions are given in various forms. The final series, representing the complete solution, appears divergent, but in practice this divergence is limited by the condition that the higher frequencies do not occur when no tuning is provided for them. The second part gives an expression for the radiating effect of an antenna in kw. referred to the mean value of the antenna current. For continuous oscillations this formula is cA^2l^2/λ^2, where A is the mean current in amps., l the effective length of the antenna, λ the wave-length, and c a constant near unity. Some considerations are put forward with regard to the best construction of antennæ, especially for directed radio-telegraphy. The free capacity and the height offer two independent means of increasing the wave-length without reducing the radiation intensity. The introduction of inductances in the antenna means a lengthening of the wave without an increase of field in the distance, though the loss of radiation effect is compensated to some extent by greater tuning facility. The importance of a great height for the upper capacity is so pronounced that it might be advisable to use a hill, or pair of hills, for supporting the upper ends. The cause of the interference of sunlight with the range of signalling is not yet clear. The author inclines to attribute it to an interference with the horizontality of the limiting layer of the conducting upper atmosphere. The conductivity of the latter may be largely due to electrons of solar origin, and these are accelerated by the passage of an ether wave. Thus, a Hertzian oscillator with an antenna current of 600 amps. is capable of imparting a velocity of about 1 km. per sec. to an electron at a distance 10 times the length of the antenna. If sunlight liberates, say, 10,000 electrons per cm.^{3} per sec., a considerable reduction in the strength of the waves must result. **P. O. Pedersen.** (Electrician, 71. p. 741, Aug. 8, 1913.)

E. E. F.

145. *Radiation of Electric Waves from a Point above the Earth's Surface.* **K. Wolf.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 197–281, Feb., 1913.)—A mathematical treatment of the space and surface waves in which it is shown that the latter are damped as $r^{-1/2}$, whereas the former are damped as r^{-2}. The solution obtained does not, however, admit of so ready a separation of the two waves as that of Sommerfeld. [See Abstract No. 569 (1912).]

E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

146. *Action of Mercury-vapour on Selenium.* **F. C. Brown.** (Phys. Rev. 2. Ser. 2. pp. 153–160, Aug., 1913.)—Mercury-vapour acts on selenium in such a manner as to produce a very high conductivity and an increase of resistance on illumination. The mercury acts on the amorphous form and probably also on the other modifications so as to produce selenium of new characteristics. Permanent chemical compounds are probably formed between the mercury and the selenium. An easy and satisfactory method of making light-negative Se is to place the amorphous Se in a mercury vacuum until it becomes black, and then to press this black Se between fixed electrodes.

E. E. F.

147. *Distance between Conducting Plates and Question as to Electron Atmospheres.* **F. C. Brown.** (Phys. Rev. 2. Ser. 2. pp. 314–322, Oct., 1913.)—In 1912, R. W. Wood [see Abstract No. 865 (1913)] raised the question as to the existence of conducting atmospheres surrounding metallic surfaces. This hypothesis arose from a number of experiments, in which electrical conduction took place between metallic surfaces separated by 20 or 30 wave-lengths of sodium light. The present author measured the distance between plates by using them as a condenser. He thus concludes that there was almost perfect insulation when the two plates were separated by ten wave-lengths and that conduction did not extend so much as two wave-lengths outside the mechanical surface.

E. H. B.

148. *Conductivity of Thin Liquid Films.* **A. Ungerer.** (Phys. Zeitschr. 14. pp. 685–688, Aug. 1, 1913.)—Films of NaCl or $HgNO_3$ solution having a thickness of the order of 10^{-4} mm. show no conductivity differing from that measured by ordinary methods, whereas many previous researches on soap films and metallic films have shown a dependence of specific conductivity on thickness. The thickness of the films was gauged by means of Newton's rings. Of two thick plates of glass, one was provided with a cylindrical boring into which a silver plate was inserted to serve as an electrode. This plate was pressed on to the other plate by means of six screws, and the pressure was so regulated that Newton's rings were concentric with the bore. A silver ring surrounding the junction between the plates was the second electrode. Thus the film of the required thickness could be reproduced at any time. The agreement between the observed conductivity and the ordinary conductivity was correct to within 3 per cent.

E. E. F.

149. *Influence of Conductivity on the Apparent Dielectric Constants of Liquids.* **W. M. Thornton.** (Univ. of Durham Phil. Soc., Proc. 5. pp. 19–25, 1912–1913.)—The behaviour of a conducting dielectric may be examined by direct measurements with steady currents or by observation of capacity currents in alternating fields. The latter case is complicated by the fact that any expression for the charge on the boundary surface contains the

product $K\rho$ of the true dielectric constant K and the resistivity ρ, and both may be influenced by changes of frequency and in the composition of the substance. The state of knowledge regarding the dielectric constants of liquids is reviewed. When measurements are made on water by contact methods K is found to be constant at 80 over a wide range of frequency. But when water is enclosed in a quartz ellipsoid suspended in a Hertzian field, so that there is no contact between the electrodes and the liquid, K falls to 8 and decreases with increase of frequency. Similar differences are observed with the alcohols. It is therefore clear that the dielectric constants of liquids other than electrolytes are affected by arranging the experiment so that no conduction currents can flow. From considerations regarding the variation of the resistivity and the refractive index of salt solutions it is deduced that the variation of K with concentration must be small. The resistivity of a conducting dielectric is the dominating factor in its behaviour in alternating fields even at high frequencies. In conclusion it is suggested that the high values of K for water and alcohol should be considered as dependent more on the electrical conductivity of the medium than upon true polarisation. The conductivity considered is that of electronic mobility within the molecule rather than of ionic mobility through the fluid.

H. W. M.

150. *Experiments on Tinfoil Contact with Dielectrics.* **G. E. Bairsto.** (Phys. Soc., Proc. 25. pp. 301–320; Discussion, pp. 321–323, Aug., 1913.)—The points examined are:—(1) The different effects of pressure and voltage upon tinfoil contact with celluloid as dielectric. (2) The effect of contact upon measurements made with alternating currents. (3) The effect of imperfect contact upon the accumulation of residual charge. Appleyard [see Abstract No. 2099 (1905] has described experiments with a condenser having tinfoil electrodes and found the apparent resistance to decrease gradually at first with increase of pressure, but finally a practically constant value resulted. Increasing the voltage was found to decrease the apparent resistance. The tests made by the author clearly show that voltage has quite as much effect as pressure in bringing about an intimate contact with tinfoil electrodes and would also seem to indicate that each acts independently of the other. By considering the geometry of the tinfoil humps an explanation of the various effects is given. For measurements of the alternating-current conductivity the influence of the bad contact is twofold. Firstly, it decreases the apparent capacity by inserting in series with the condenser under test a very large air condenser. Secondly, because of the decrease in area of contact, it decreases the magnitude of that component of the conductivity which is independent of the frequency—*i.e.* the purely ohmic conductivity. By considering the system as equivalent to a leaky condenser in series with a very large capacity, expressions are deduced for the equivalent capacity, conductance, and power factor. Finally, the influence of imperfect contact upon the accumulation of residual charge is considered. It is shown that if we have a condenser with tinfoil electrodes the recovery of a residual charge is obscured by the presence of creeping surface charges coming out of the undischarged portions of the dielectric, leading to an apparent residual charge greater than the true residual charge left in the dielectric.

F. E. S.

151. *Capacity of Wire Netting.* **P. O. Pedersen.** (Jahrbuch d. Drahtlosen Telegraphie, 7. pp. 484–488, Sept., 1913.)—The problem of calculating the capacity of a wire netting parallel to a conducting surface is approached by a consideration of the corresponding problem for current. The average capacity, C_0, per sq. cm. is given by

$$C_0 = 1/2d\left[\log\left(e^{2\pi a/d} - e^{-2\pi a/d}\right) + \log\frac{d}{2\pi\rho}\right].$$

Here d = distance between two neighbouring wires of the netting, a = distance between netting and conducting surface, p = radius of the wire of the netting. T. P. B.

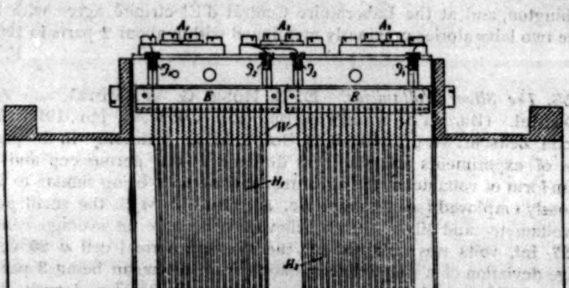
152. *Resistance Unit of the Physikalisch-Technische Reichsanstalt.* **W. Jaeger** and **H. v. Steinwehr.** (Zeitschr. Instrumentenk. 33. pp. 293–305, Oct., 1913. Communication from the Physikal-Techn. Reichsanstalt.)—A detailed account of measurements on many resistance standards. The Reichsanstalt have 5 mercury standards of resistance and have 5 others in course of construction. Comparisons from time to time show that the principal manganin resistance standards have kept very constant during the past 20 years, the max. variation being 22 parts in a million. Observations on the effect of variable atmospheric humidity on unsealed coils of manganin have been continued, and the conclusion is that changes due to such a cause are, in general, very small. Changes of 1 part in 1000 can only occur in badly constructed coils, and such changes will occur whether the coils are hermetically sealed or not. The results of certain international comparisons show that the mercury standards of resistance of the Reichsanstalt and of the National Physical Laboratory differ by less than 2 parts in 100,000 and that the resistance units used at the Bureau of Standards, Washington, and at the Laboratoire Central d'Électricité, agree with those of the two laboratories previously mentioned within about 2 parts in 100,000. F. E. S.

153. *The Silver Voltameter.* **E. B. Rosa, G. W. Vinal,** and **A. S. McDaniel.** (Bureau of Standards, Bull. 9. pp. 493–551, Jan., 1913. Elektrotechn. Zeitschr. 34. pp. 1168–1169, Oct. 9, 1913. Extract.)—In the present series of experiments attention was directed to the porous cup and non-septum form of voltameter, the apparatus and methods being similar to those previously employed [see Abstract No. 501 (1913)]. With the small porous cup voltameter and silver nitrate believed to be pure an average value of $1{\cdot}01827_5$ int. volts was obtained for the Western normal cell at 20° C., the average deviation of a single determination from the mean being 3 parts in 100,000. With the large porous cup voltameter heavier deposits by 6 parts in 100,000 were obtained and with the siphon voltameter the deposits were 30 parts in 100,000 heavier than with the small porous cup voltameter. The filter-paper voltameter gave results varying with the amount of paper immersed in the solution, but the mean was about the same as obtained with the siphon form; the Poggendorf voltameter gave results about 7 parts in 100,000 greater than those obtained with the small porous cup. Further experiments with the siphon showed that when a porous cup was placed over the kathode end of the siphon a lighter deposit of silver resulted. In general, the larger the size of the voltameter the heavier was the deposit, and this effect was called the "volume effect." With pure solutions there should be no such effect. With regard to used solutions, they are purer than the original solutions if the latter were impure. For testing the purity of silver nitrate special methods have been devised. Estimations of the acidity may be made within 1 part in 100,000 using iodeosin as an indicator. For testing the

solutions for reducing agents and colloidal silver, $\frac{1}{1000}$th normal potassium permanganate is employed. Methods of preparing pure silver nitrate are fully described, the fusion of the salt being discussed with particular reference to its decomposition after all of the acid has been expelled. The temperature-coefficient of the voltameter was found to be zero and deposits on gold and platinum kathodes are in agreement. F. E. S.

154. *Metallic Rectifiers.* **W. Winter.** (Phys. Zeitschr. 14. pp. 823–828, Sept. 1, 1913.)—Besides aluminium, many metals show a rectifying electrolytic action when the precaution is taken of introducing a porous substance, such as unglazed earthenware, between the electrolyte and the metal acting as an anode. The author examined a number of metals in this way, using carbon as a kathode, and allowing for the slight voltaic current due to the difference of electrode material. In dilute KHO the following metals showed a rectifying action: Mg, Al, Zn, Cd, Fe, Co, Ni, Pb, Sn, Sb, Bi, Cu, Ag, Pt, Au, and Cr. All these, except the three last, also acted in dilute H_2SO_4. Gold amalgam on gold also acted in dilute H_2SO_4. The enhanced action due to the porous partition is ascribed by the author to the greater concentration of the dissociation products. E. E. F.

155. *Electrical Anemometer.* **H. Gerdien.** (Elektrotechnik u. Maschinenbau, 31. pp. 893–895, Oct. 19, 1913. Paper read before the 85. Naturforscherversamml. Vienna.)—The apparatus described has the following advantages: (1) Readings may be taken quickly, (2) absence of moving parts, (3) measurements may be recorded at a distance. The stream of gas to be measured passes through a tube in which two Pt-wire resistances are suspended. The resistances (H_1 and H_2 of the Fig.) are stretched in zigzag fashion in a diametral plane of the tube (the plane of the figure), and are kept taut by Pt-Ir springs (W) which are fixed to ivory blocks (E). These two resistances form arms of a bridge, which is adjusted so that the galvanometer reads zero when no gas flows through the tube, and the battery maintains a current in them which raises their temperatures about 50 deg. C. above that



of the gas. When a current of gas passes the resistances they are cooled unequally and a galvanometer deflection results. The instrument must be calibrated for the particular gas in which it is to be employed. For measuring the stream of gas in a large pipe the measuring tube is connected in parallel with it so as to shunt a definite proportion of the stream. To measure wind velocities the apparatus is connected by tubes to the front and back of a baffle-plate kept normal to the wind. A temperature compensation device is described for use in this connection and also an arrangement which enables the velocity of the wind and its inclination to the horizontal to be simultaneously determined. F. T. C.

156. *Electric Properties of Tempered Steel.* **U. Bordoni.** (N. Cimento, 5. Ser. 6. pp. 412–436, June, 1913.)—The effect of the temperature to which the steel is heated for being tempered in a liquid at ordinary temperature is examined, both in the case of the thermoelectric property and of specific resistance. The methods of heating and of quenching are described, and also the experimental arrangements for measuring the electric properties. Six kinds of steel are examined, the results being the same qualitatively but differing quantitatively. For measuring the thermoelectric effects a steel-copper couple is used, and it is found that before tempering the steel has a small negative thermoelectric power with respect to copper, but this continuously changes to a considerable positive value as successively higher temperatures are used for the heating required for tempering. The rise is rapid at first, but eventually becomes slow, a limiting value being approached. At the same time the resistivity falls, also rapidly at first but slowly afterwards, and simultaneously the coefficient of increase of resistance with temperature rises by a very small amount. The effect of tempering in liquids of different temperatures is also touched upon. S. G. S.

157. *Astatic Vacuum Radio-micrometer.* **K. P. Jakovlev.** (Russian Physico-Chemical Soc., Journ. 44. No. 8. pp. 459–469, 1912.)—To overcome the defects of want of sensitiveness manifested in earlier radio-micrometric apparatus the author uses the principle of astaticism, a thermopile being placed inside the gap. The thermo-element is composed of a Pt and gun-metal wires 0·02 mm. in diam., soldered together so as to form a butt joint. The period without the magnetic field is 26·2 secs.; within field, 7·0 secs. The sensibility rises from 90·1 with a period of 7 secs., to 740 at 21·9 secs. Numerous details of construction of the instrument are given, and the effect of vacuum is examined, the results being given in the table below :—

EFFECT OF VACUUM.

Pressure in mm.	Deflect. on Scale.	Pressure in mm.	Deflect. on Scale.
760	9·5	760	11·0
7	10·1	6	11·8
1·15	14·15	0·51	21·65
0·49	19·3	0·12	43·5
0·10	38·5	0·039	68·75
0·044	52·45	0·02	82·0
0·021	65·6	0·011	88·5
0·008	77·0	0·0028	96·7
0·0038	82·0	0·0003	100·5
0·0016	85·0	0·0002	101·0
0·0003	87·3		
0·0002	87·8		

I. P.

158. *An Interrupter for Heavy Currents.* **B. Thieme.** (Phys. Zeitschr. 14. pp. 904–905, Sept. 15, 1913.)—Instead of using high-frequency transformers, the author proposes a high-frequency interrupter in a 220-volt circuit. The interrupter consists essentially of a brass or copper disc with a smooth rim, kept in rotation by a motor. A carbon rod is pressed tangentially against the rim. The trace of eccentricity invariably present suffices to interrupt the current. The arc is drawn out in the direction of motion of the disc, but as the pressure and the speed are increased the arc shortens, and at a certain critical pressure the contact becomes continuous. A pure note may be obtained by choosing a speed of rotation in resonance with the period of transverse vibration of the rod. The current interrupted may be as strong as 15 amps. The rod has to be tightened about every half-hour, but the disc keeps cool and shows no wear. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

159. *Alternate Currents Demonstrated by Manometric Flames.* **H. Nagaoka.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 116–118, July, 1913.)—The alternate character of currents may be demonstrated by an electromagnet acting on the membrane of a manometric flame. The frequency can be ascertained by comparison, in a rotating mirror, of the pattern of flames due to the alternating current with the pattern of flames due to a source of sound of known pitch. E. H. B.

160. *Effect of Thermal Treatment and of Longitudinal Strain in Inducing Sensitive State.* **M. B. Moir.** (Roy. Soc. Edinburgh, Proc. 33. pp. 243–256, 1912–1913.)—In carbon steel the most susceptible part of the temperature scale in producing sensitive state is about 150° C. [see Abstract No. 2028 (1908)], whereas in tungsten steel the corresponding temperature is about 300° C. the effect being much smaller. Longitudinal strain has an effect similar to that caused by thermal treatment. The results in each case are given for five different specimens. G. E. A.

161. *Coercive Force of Nickel.* **R. Gans.** (Ann. d. Physik, 426. pp. 1065–1072, Dec. 23, 1913. Phys. Zeitschr. 14. p. 831, Sept. 1, 1913.)—Determines the coercive force of Ni from the temperature of liquid air up to 612° C. It ranges from 29 to 3·918 gauss. If C is the coercive force at T° abs., and C_0 the same at the absolute zero (29·4 gauss), then the results are given by $C/C_0 = 3L(x)/x$, where $L(x) = \coth x - 1/x$. Also, $T/\theta = L(x)$, where θ is Curie's temperature of disappearance of ferro-magnetism. Weiss makes this 631° C. E. E. F.

162. *Effect of Changes of Electrical Resistance upon Magnetisation of Nickel.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 33. pp. 200–224, 1912–1913.)—In a former paper [Abstract No. 1159 (1904)] the author described observations on the relation between magnetisation and resistance in nickel at high temperatures, the magnetisation being along the direction in which the resistance was measured. Later a series of measurements was made in which the magnetisation was transverse to the direction in which the resistance was measured. In these later measurements a flat coil of nickel wire was used and very high fields were necessary. The results indicated that the magnetisation, and not the magnetising force, was the determining factor. Thus the form of the material employed was important and thin

nickel sheeting was used, the change of resistance of a nickel strip when magnetised transversely being easily measurable in moderate fields when sensitive apparatus was employed. In the present paper the results of measurements made when nickel was subjected to a combination of two fields, longitudinal and transverse at the same time, are described. A strip of Ni of width 2·1 cm. and of resistance 0·0378 ohm was doubled over and rolled up like a tape measure so as to form an anchor-ring core for a transformer-wound coil. The neighbouring turns of the Ni were insulated by interleaved asbestos sheeting, and the magnetising coil was wound round in two layers, there being 57 turns in the inner layer and 51 in the outer. The coil finally formed a roughly elliptical anchor ring with external diams. 4 and 3·5 cm. and interior diams. 1·7 and 1·3 cm. In this regarded as electromagnetically equivalent to a circular anchor-ring of radius 1·31 cm. one ampere passing through the magnetising coil will produce an average field of 16·5 gauss. This coil was then placed axially in the gap of a solenoid consisting of 6 large coils placed end to end, 3 on each side of the gap. The field within the gap for various currents passed through the solenoid was measured by means of a Bi coil. The lines of magnetic force due to this field ran across the nickel, *i.e.* transversely to the magnetic field established in the anchor-ring coil enclosing the strip. The nickel strip was made to form the greater part of one arm of a Wheatstone bridge, an approximate balancing being secured by adjustment of the point of contact on a stretched wire. By suitable arrangements the proportionate change of resistance in the arm containing the nickel was readily calculated, a calibrating shunt being used to change slightly one of the known resistances of the bridge. A full record of the results obtained is given in the paper in a series of tables and the significance of the numbers is shown clearly by means of a set of representative graphs. The phenomena may be summarised thus:—(1) When a nickel strip is conveying a current its conductance is diminished in a longitudinal magnetic field, increased in a transverse magnetic field. (2) Reversal of either magnetic field does not change the accompanying effect on the conductance. (3) When a cyclic longitudinal field is superposed upon a steady transverse field of magnitude less than a certain critical value the diminution in the conductance is less marked as the transverse field increases and practically vanishes when this critical value of transverse field is reached. (4) When the steady transverse field exceeds this critical value the superposed cyclic longitudinal field causes an increase in the conductance, and this increase becomes more marked as the longitudinal field is made greater. (5) When a cyclic transverse field is superposed upon a steady longitudinal field the increase in conductance is augmented. Not only does the increase of conductance grow greater with the stronger transverse field but it also grows greater as the steady longitudinal field is increased. The observed effects are evidently due to a remarkable molecular and intermolecular action. The explanation according to the electron theory is discussed, but the author concludes that no simple theory of orientation of magnetic molecules can at all fit in with the facts. An explanation must be sought in some more complex process in which the grouping of the magnetic molecules and even the internal structure of each magnetic molecule are of fundamental importance. J. J. S.

163. *Magnetic Researches.* VII. *Paramagnetism at Low Temperatures.* **H. Kamerlingh Onnes** and **E. Oosterhuis**. (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 965–971, April 24, 1913. Communication No. 132*e*

from the Phys. Lab., Leiden.) [See also Abstract No. 693 (1913).]—The authors first give a table of results for crystallised manganese sulphate, whereby it is shown that down to and at nitrogen temperatures the law of Curie is obeyed. The case of the anhydrous salt is then dealt with, the water having been expelled from the crystallised variety by heating. Here divergence from Curie's law over the whole field of low temperatures was found, although down to nitrogen temperatures it is only a disturbance of the first kind. At hydrogen temperatures, however, a further disturbance occurs not unlike those with solid oxygen. The authors point out the analogy with crystallised ferrous sulphate, where the presence of molecules of water of crystallisation causes a diminution of the quantity Δ' to a very small value in comparison with that of the anhydrous substance. Further observations upon pure ferrous and ferric sulphates are then recorded, since the previous specimens investigated in Com. No. 129*b* were found to have been contaminated. The quantitative result arrived at in Com. No. 129*b* concerning the appearance of the first kind in Curie's law, and the possibility of finding the constant of Curie for these substances by means of a correction, is found to retain its value. Should the disappearance of Δ' with the introduction of water molecules be ascribable to the increase of distance between the iron atoms which is caused thereby, then Δ' should decrease with increase in number of molecules of water of crystallisation, and the authors therefore intend to examine a salt which crystallises in a series of different hydrates so as to ascertain whether Δ' depends on the density. A table of results is next given for pure Pt, while a reference to dysprosium oxide is made. The susceptibility of liquid oxygen has previously been determined by H. K. Onnes and Perrier in two ways, and now follows a third by the attraction method whereby an evacuated cylindrical glass tube is hung in the magnetic field and the repulsion experienced by the tube is measured when the surrounding space is filled with liquid oxygen. Tables are given, and the results discussed. A private communication by Weiss is then quoted, in which it is suggested that there might be discontinuity in the region between 0° C. and —183° C. Finally, experiments still incomplete are referred to, in which it appears probable that gaseous oxygen of 90 times the normal density obeys Curie's law down to —130° C. H. H. Ho.

164. *Magnetic Researches.* VIII. *The Susceptibility of Gaseous Oxygen at Low Temperatures.* **H. Kamerlingh Onnes** and **E. Oosterhuis.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 1404–1406, July 15, 1913. Communication No. 134*d* from the Phys. Lab., Leiden.)—The paper deals with results for compressed oxygen between 17° C. and temperatures near the critical temperature. The attraction method previously noticed was used for the determinations, and a graphic representation is given of the data obtained. Within the limits of accuracy in the measurements a Δ does not yet appear in oxygen above the critical temperature at densities which are 100 times the normal. From this it seems all the more probable that Δ only appears for oxygen at great densities, and in liquid oxygen can rise to the considerable value of 71° as the density rises to 1000 times the normal.
H. H. Ho.

165. *Magnetic Researches.* IX. *Deviations from Curie's Law in Connection with the Zero-point Energy.* **E. Oosterhuis.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 432–440, Nov. 27, 1913. Supplement No. 31 to the Communications from Phys. Lab., Leiden.)—The paper commences with a

review of known deviations from Curie's law, which is that for a number of paramagnetic substances the susceptibility is inversely proportional to the absolute temperature. Onnes with his collaborators found that a substance which follows the law at higher temperatures may begin to deviate from it at lower. This investigation at low temperatures promised to give an insight into the nature of paramagnetism, and from the results obtained with several substances the author and Onnes were led to the conception that for all paramagnetic substances, or at least for one class of them, the deviations from Curie's law are governed by a law of corresponding states, the corresponding temperature for each substance to be taken proportional to a certain temperature characteristic of that substance. The majority of the substances investigated in the cryogenic laboratory at Leiden may be reduced to the following three types: (*a*) Those such as crystallised ferrous or manganese sulphate, etc., where the relation $\chi T =$ const. holds as far down as the temperatures of liquid nitrogen, but where at hydrogen temperatures χT was always smaller than would follow from Curie's law. (*b*) Those such as anhydrous manganese sulphate in which the product χT began to diminish at once when the temperature was lowered below room-temperature; in this case $\chi(T + \Delta) =$ constant held up to nitrogen-temperatures, but failed in liquid hydrogen. (*c*) Those such as Pt, in which the susceptibility appeared almost independent of temperature. The author then puts forward a theoretical explanation of the deviations from Curie's law. The latter was theoretically deduced by Langevin in his kinetic theory of paramagnetism where the susceptibility is found to be inversely proportional to the kinetic energy of rotation of the molecules. This latter assumption is dropped by the present author in favour of a different temperature relation based on Einstein and Stern's work for the rotational energy; and a mathematical demonstration is then given accompanied by illustrative tables, which show the inclusion of a zero-point energy to be necessary. Reference is also made to results obtained by a different formula which takes into account the possibility of more than one frequency of rotation, whereas Einstein and Stern assumed that at a definite temperature all the molecules rotate with the same velocity. In conclusion, the author summarises the various investigations which have made probable the existence of a zero-point energy as follows:—(1) The change of the specific heat of hydrogen at low temperatures has been explained by Einstein and Stern in a satisfactory manner by the assumption of a zero-point energy. (2) The assumption of a zero-point energy for the translational motion of gas-molecules appears to be also required. (3) Keesom has shown that the quanta theory with the additional assumption of a zero-point energy is of great importance in the theory of free electrons in metals, and removes a number of difficulties inherent in the equipartition-theory. (4) In the present paper it is shown that the assumption of a zero-point energy for the rotations finds a strong support in the observations on the susceptibility of paramagnetic substances; it appears that by means of it the majority of the deviations from Curie's law observed at low temperatures may be correlated and quantitatively explained in a satisfactory manner. H. H. Ho.

166. *Change of Length in Magnetite with Magnetisation.* **K. Yamada.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 170–174, Oct., 1913.)—Two elongated rectangular specimens of nearly pure magnetite were tested for change of length by means of a simplified form of the apparatus used for a similar purpose by Nagaoka. Hysteresis curves were first drawn, from which it appeared that the coercive force of magnetite is greater than that of soft

iron, and the intensity of magnetisation is about half that in nickel. The energy dissipated during a cycle (for $H = \pm 288$) was 54,400 ergs. The change of length takes place very slowly in weak fields, but goes on gradually increasing at a steady rate, so that max. elongation was not observed in a field of several hundred gauss. The hysteresis in elongation is quite remarkable, and resembles that in iron in weak fields. When elongation is plotted against magnetisation, the hysteresis is nearly evanescent, showing that elongation and magnetisation are intimately connected in the cycles. G. E. A.

167. *Sun's Influence in Magnetic Storms.* **A. L. Cortie.** (Roy. Astronom. Soc., M.N. 73. pp. 539–543, May, 1913.)—In former papers the author has pointed out that an area of sun-spot disturbance may be accompanied by several magnetic disturbances as it traverses the sun's disc. Such storms occur in batches, sometimes on several succeeding days, the angular separation of the sun-spot and the earth's position in heliographic longitude being at times considerable. Evidence of a type of localised effect, due possibly to sets of rays or streamers, has been adduced from the discussion of eclipse pictures of the solar corona [see Abstract No. 1734 (1913)], and in the present paper additional evidence of this nature has been collected from the eclipse results of 1893, April 16. The results on the whole appear to strengthen the view that the mode of influence is in the form of rays diverging from loci of sun-spot disturbance, such rays being probably carriers of negatively-charged electrons. As these particles recede into space they would repel each other, resulting in the formation of clouds of particles. The double curvature of some of the streamers of the solar corona appears to be evidence of some such mutual repulsion. C. P. B.

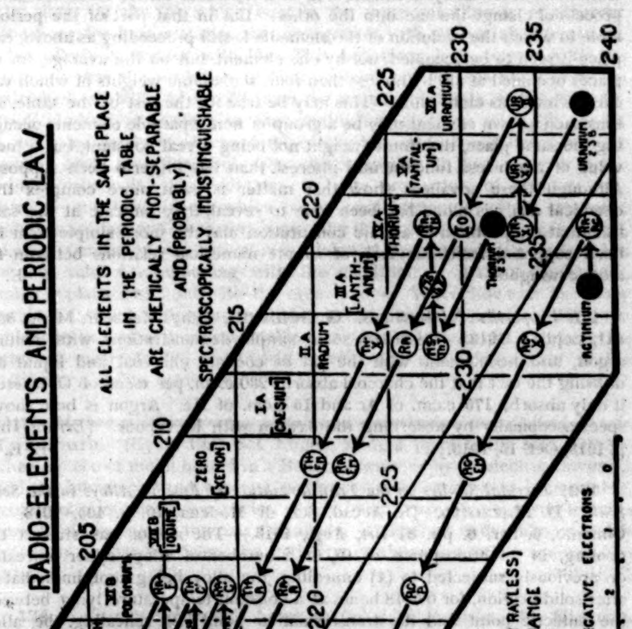
RADIOLOGY AND ELECTROPHYSIOLOGY.

168. *Determination of the Time of Exposure of a Radiograph.* **T. Nogier.** (Archives d'Él. Médicale, 21. pp. 368–374, Oct. 25, 1913.)—The exposure tables of Grisson, and also that of R. Heller and Mylius are given and explained. A diagram of the exposure time indicator of Gaiffe is given and these three methods of obtaining the correct time of exposure are compared. It is concluded that the figures given by Grisson and Gaiffe represent a minimum of exposure below which it is not usually possible to obtain a good negative, while those of Heller and Mylius represent a maximum of exposure above which the image becomes very black and the negative very dense. The Gaiffe indicator is recommended on account of the fact that all conditions of exposure are taken into consideration. A. E. G.

169. *Means of Avoiding Burns by Röntgen Rays.* **M. Ménard.** (Comptes Rendus, 157. pp. 868–870, Nov. 10, 1913.)—A general protective arrangement with lead is described and, after a discussion on gloves in common use, which are by no means satisfactory in preventing the passage of the harder rays employed, a new glove material is described. It consists essentially of an indiarubber tissue in the composition of which salts of a metal of high atomic weight are employed. With gloves of this material 4 mm. in thickness, the hands of the operator are completely protected even against very hard rays. The complete outfit is regarded as capable of preventing any injurious results when using Röntgen rays. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

170. *Radio-elements and the Periodic Law.* **F. Soddy.** (Chem. News, 108. pp. 168–169, Oct. 3, 1913. Abstract of paper read before the British Assoc. at Birmingham.)—A *résumé* of recent work on the passage through the periodic table of the elements in process of radio-active change [Abstracts Nos. 1074, 1075, and 1079 (1913)]. The author shows that it is possible to write the three disintegration series of Ur, Th, and Ac across the periodic table, so that each member falls into its proper place as above: the general law is that in an α-ray change the element changes its place in the periodic table in the direc-



tion of diminishing mass and diminishing group number by two places. In a β-ray change the element changes its position in the table in the opposite direction by one place. Further, all elements falling into the same place in the periodic table, such as Th, Radio-Th, UrX, and Io, are not merely similar to chemical properties, but are chemically identical, non-separable by chemical methods and probably spectroscopically indistinguishable. The chemical analysis of matter is thus not an ultimate one. It has appeared ultimate hitherto, on account of the impossibility of distinguishing between elements which are chemically identical and non-separable unless these are in the process of change the one into the other. But in that part of the periodic table in which the evolution of the elements is still proceeding as above, each place is seen to be occupied, not by one element, but on the average, for the places occupied at all, by no less than four, the atomic weights of which vary over as much as eight units. This may be true for the rest of the table, and thus each known element may be a group of non-separable elements occupying the same place, the atomic weight not being a real constant, but a mean value of much less fundamental interest than has hitherto been supposed. Although these advances show that matter is even more complex than chemical analysis alone has been able to reveal, they indicate at the same time that the problem of atomic constitution may be more simple than has been supposed from the lack of simple numerical relations between the atomic weights. E. M.

171. *Properties of Noble Gases.* **G. Gehlhoff.** (Phys. Zeitschr. 14. pp. 838–841, Sept. 1, 1913.)—Describes some simple demonstrations with helium, argon, and neon, made with the aid of coconut charcoal and liquid air, utilising the fact that the charcoal absorbs 230 c.cm. per c.cm. of O, whereas it only absorbs 175 c.cm. of Ar and 15 c.cm. of He. Argon is best shown spectroscopically by absorbing the oxygen with Kr vapour. [*Errata,* Ibid. p. 1013, Oct. 15, 1913.] E. E. F.

172. *Thermal Studies on the Transformation of Fusible Alloys in the Solid State.* **D. Mazzotto.** (R. Accad. Sci. di Modena, 10. p. 405, 1913. N. Cimento, 6. Ser. 6. pp. 81–104, Aug., 1913.)—The author has studied the cooling, in an atmosphere of 0°, of a number of alloys either untreated or previously subjected to (1) annealing, the alloy being kept, immediately after solidification, for 0·5–48 hours at a constant temperature lying between the eutectic point and the transformation point; (2) reheating, the alloy being allowed to cool in the ordinary way to the temperature of the air and then heated for 0·5–48 hours at a constant temperature; (3) reheating, preceded by quenching in cold mercury. The method employed is based on the determination of the ratio R_1 between the durations of cooling of the alloy and of mercury through similar intervals of temperature. The normal value, R, of this ratio, that is, its value provided that the alloy exhibits no evolution of heat owing to change of state or other reason, is determined either by extrapolation of the experimental results or by calculation from the values of the ratio for the constituent metals of the alloy. From $\Delta = R_1 - R$ the amounts of heat evolved in the separate temperature intervals are given in hundredths of a calorie per kg. of alloy by the expression $q = \Delta . 217/P$, where P is the weight of the alloy in gm. and 217 a coefficient depending on the thermal capacity of the crucible filled with mercury. Alloys of the following compositions in parts by weight were examined, but the first four show no exothermal behaviour in the solid condition;

(1) 1 Tl + 2·7 Bi ; (2) 3 Zn + 2 Sn ; (3) 2 Zn + 3 Sn ; (4) 1 Pb + 1 Bi ; (5) 1 Sn + 1 Bi ; (6) 4 Sn + 1 Bi ; (7) 2 Pb + 1 Sn ; (8) 3 Sn + 2 Tl ; (9) 1 Sn + 1 Cd. Where heat is evolved by the solid alloy, four successive phases are conveniently distinguished : (1) the initial phase, in which the evolution becomes sensible and gradually increases ; (2) the explosive phase, in which the maximal evolution occurs, sometimes accompanied by recalescence ; (3) a diminishing phase ; and (4) a final or vanishing phase. The various thermal treatments described above have a marked influence on the heat of transformation which then varies from 0·99 cal. for alloy (5) to 1·87 cals. for alloy (7). With alloys (5) and (6), which contain the same constituents in different proportions, the heat evolution is at first greater with (5), but after treatment of the alloys is greater with (6). This behaviour is in accord with the hypothesis that the evolution of heat depends on the separation, owing to diminished solubility, of the Bi from the mixed crystals in which it is dissolved. Indeed, according to the equilibrium diagram, alloy (6) should be composed solely of saturated mixed crystals, and should hence exhibit maximal heat evolution ; but after direct cooling it gives only a feeble evolution, since it then contains a large proportion of slightly concentrated crystals, from which only small amounts of Bi separate ; during annealing and reheating, especially if this is preceded by quenching, the alloy is enriched with saturated crystals and the heat evolution approaches the max. value corresponding with the condition of perfect equilibrium. Similar explanations hold with the other alloys. When, however, the latter contain tin, which undergoes an allotropic transformation at about 161°, the diminution in solubility is attributable partly to the lowering of the temperature, and partly to the diminished solvent and dissolving power of the modification stable below 161°. T. H. P.

173. *Method of Disintegrating Metals and their Oxides into a Colloidal State.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 211–213, May, 1913.)—When a piece of metal heated in a Bunsen burner or by an electric current is suddenly introduced into water, it undergoes disintegration to some extent, yielding ultramicroscopic particles, which, in most cases, travel partly towards the kathode and partly towards the anode. Oxides or hydroxides of metals also form similar particles, the majority of these migrating towards the kathode. T. H. P.

174. *Nature of the Double Layer in Colloidal Particles.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 201–209, May, 1913.)—J. J. Thomson's theory (Phil. Mag. 36. p. 320, 1893) affords a good explanation of the dissociation of substances when these are brought together, but is not able to explain the formation of the electric double layer at the surface of separation between two bodies. The complete separation of the dissociated charges is explained in two ways : as due either to the specific action of the dissociated ions or to the specific attraction of the medium on the dissociated ions. If these two views are adopted, the formation of the double layers may be regarded as follows : When a metallic hydroxide, which is a positive colloid, is placed in water, it is slightly dissociated into positive metal ions and hydroxyl ions owing to the dissociating power of water with its high dielectric constant. On account of their osmotic pressures, ions of both kinds diffuse, but the hydroxyl ions have the greater velocity, and hence proceed the further into the water, a partial separation of the ions thus taking place. When this stage is once reached the attraction of the positive ions prevents further diffusion of the hydroxyl ions. Thus the double layers are formed, the positive coatings being in the case of a positive colloid on the surfaces of the colloidal particles and the negative ones on the water side of the surfaces of separation. There is also evidence indicating some interaction between the ions and the medium; for instance, Wilson's experiments [Abstract No. 1025 (1900)] and the reduction of the velocity of ions in dry gases by a trace of water-vapour, an effect especially marked with negative ions [see Zeleny, Abstract No. 1919 (1901)]. Analogous explanations may be applied to the formation of the double layer with a negative colloid and to the influence of an electrolyte or of a non-electrolyte on the stability of colloidal solutions. T. H. P.

175. *Corrosion of Metals covered with a Thin Layer of Water or an Alcohol and subjected to the Action of Ultra-violet Rays.* **M. Kimura.** (Kyōtō Coll. Sci. Engin., Mem. 5. pp. 258–260, May, 1913.)—Although Svedberg [Abstract No. 1201 (1910)] regards the disintegrating action of ultra-violet rays on the surface of a metal immersed in water or an alcohol as a secondary effect of the rays, the results of Lenard and Wolf [Wied. Ann. 37. p. 443, 1889] and of H. Rubens and E. Ladenburg [Abstract No. 446 (1908)] suggest that the rays exert a direct action in this respect. The author has repeated Svedberg's experiments and has also investigated the cataphoresis of the colloidal particles formed as a result of the disintegration of the metals. It was found that some of the particles travel in the direction of the current and others in the opposite direction, showing that the colloidal particles are of the metal and its hydroxide. The surface of the metal was observed to be corroded, and investigation showed that the etching action of the rays is favoured more by the presence of water than by that of air or oxygen. In the former case the action is due partly to hydrogen peroxide, and in the latter partly to ozone, but the phenomena observed are not completely explainable in this way. The author regards these phenomena as closely connected with photoelectric phenomena and explains them as follows:—A metal placed in water dissolves slightly in the form of positive ions owing to their solution tension, so that a double layer is formed on its surface, the positive ions of metal lying on the outer coating. The influence of ultra-violet rays on such a surface causes the electrons in the inner coating of the double layer to fly out and unite with positive metal ions in the outer coating. This union transforms positive ions into free neutral atoms, which separate from the metal. At this stage some of the atoms act on the surrounding water with formation of hydroxide, whilst others give molecules of the metal. If the double layer is destroyed in this way another portion of metal dissolves in the form of positive ions, a double layer being again formed and subsequently destroyed by the action of the rays, and so on. These processes continue so long as illumination with the ultra-violet rays persists. If this explanation is correct, antimony should exhibit greater resistance to the action of the rays than cadmium, and this is actually found to be the case.
T. H. P.

176. *Passage of Nascent Hydrogen through Iron.* **M. Bellati and S. Lussana.** (N. Cimento, 5. Ser. 6. pp. 389–392, May, 1913.)—The results recently published by Charpy and Bonnerot [see Abstract No. 1121 (1912)] confirm those obtained by the authors (R. Istituto Veneto Atti, 1888–1891).
T. H. P.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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